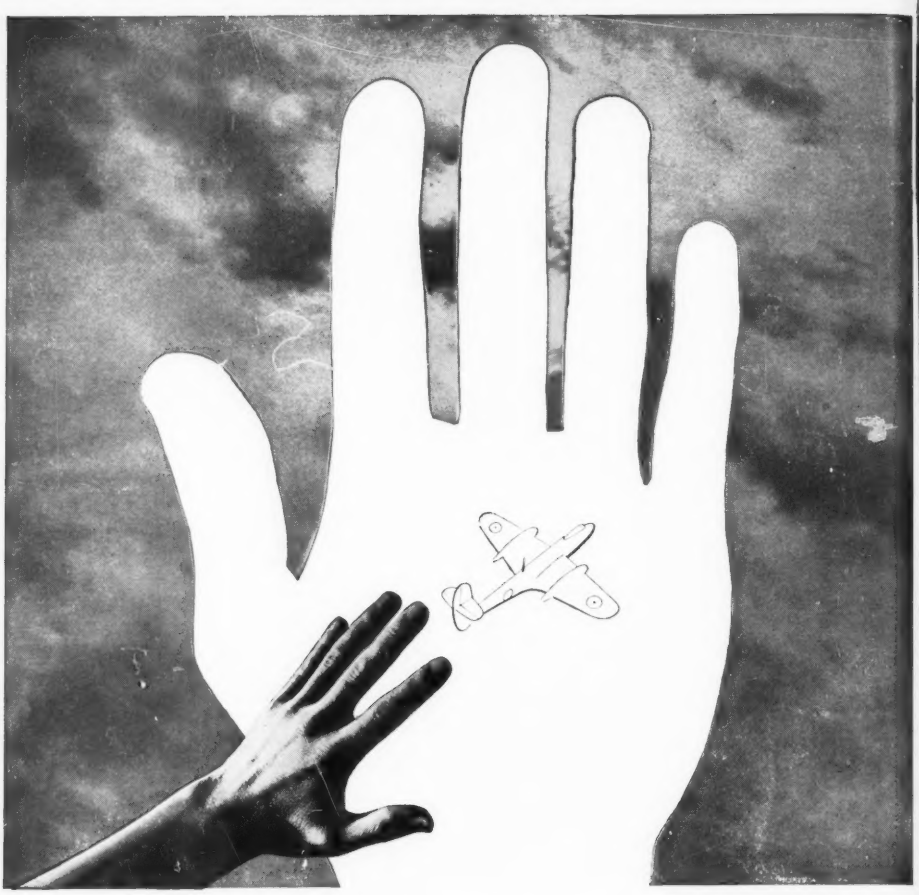
The Journal of

THE ROYAL AERONAUTICAL SOCIETY



we can start and stop almost anything

When it comes to stopping modern high speed aircraft people in the Industry almost automatically think of B.B.A., because MINTEX brake linings are used on practically all British Aircraft. This supremacy, in the most exacting field of all, is the result of years of research and experimental work, the benefits of which are applied to the manufacture of all B.B.A. friction materials. No wonder they say — " When you've got to stop you can rely on MINTEX."

BRITISH BELTING AND ASBESTOS LIMITED

CLECKHEATON, YORKSHIRE

Spinners, weavers and manufacturers of Asbestos Yarns, Cloths, Tapes, Packings and Jointings. Manufacturers of Machinery Belting for Industry; Manufacturers of MINTEX brake and clutch linings and other friction materials.

THE ROYAL AERONAUTICAL SOCIETY

GRADUATE AND STUDENT SECTION

January 1950.

The following is a summary of the Presidential Address delivered to the Graduate and Student Section by Sir John S. Buchanan, F.R.Ae.S., on 13th October 1949.

THE TIME SCALE IN AERONAUTICAL ENGINEERING

The purpose of this lecture is to trace the evolution of an aircraft with special reference to the position of each stage in the time scale which, of recent years, has become of great importance. The increasing complexity and size of aircraft have resulted in a prolonged design process involving much labour, all of which has to be justified economically. Thus a critical study of the time scale is of great value in the hope that unnecessary wastage may be eliminated.

In the first instance, the appropriate Ministry prepares a specification anticipating future requirements, which task normally occcupies three to six months. When the manufacturer receives the specification, he prepares project and mock-up drawings, calculations of a fundamental nature, cost estimates and the anticipated time scale, all of which are submitted to the Ministry. This project stage will occupy approximately three months for a small aircraft, and six months for a large machine, during which period there is considerable discussion between manufacturer and Ministry in defining specification details. The manufacturer will have been faced with the difficulty of fixing the price of the aircraft, which cannot be estimated to a high degree of accuracy until the prototype has been constructed. Furthermore, a policy of low initial cost may result in an aircraft of high operational costs because of poor performance. Thus it is generally accepted that a tender will be judged mainly on the technical efficiency of the project, provided that the price is not excessively high, and proposals for meeting the specification are framed with this in mind.

A period of two months may elapse while the Ministry consider the project, after which the manufacturer may expect an order for one or more prototypes, as required. In wartime a substantial production order is given with that for the prototype which, provided that no serious obstacles arise, may enable the time taken to introduce a type into service to be halved. If difficulties do arise, whole batches of parts may have to be scrapped, instead of merely the prototype part. Such a risk is justifiable in an emergency but cannot be tolerated in peacetime, although it has been tried abroad and frequently has resulted in the redesign of major components at a heavy loss.

The manufacturer will spend at least 18 months in the actual design stage and 24 months would be a more realistic figure. Some 400,000 man hours may be expended in the drawing office in the course of which 15,000 drawings will be issued for a large aircraft. This corresponds to 200 man years, which might be taken to imply that a staff of 200 should complete the task in one year. It must be remembered, however, that it is impossible, at any instant, to transfer the complete staff *en bloc* to a new project. There will be work in hand at the time the project is started and, initially, few draughtsmen will be available, the number being stepped up on completion of previous designs and depending on the relative importance of the projects being undertaken.

Main Re
770577

Parallel with the preparation of drawings, there will be a considerable amount of pre-production planning to be done involving ordering of materials and tooling up. In particular, early notice must be given in ordering castings, extrusions and forgings, especially where they are of a complicated nature. Failure to do so will result in severe delays, aggravated by the fact that fabrication by alternative methods is seldom practicable. A good forging of a special nature may only be ready a year after ordering, hence such items should be avoided in the design if possible. If a forging is to be used, it is preferable to hand forge it if possible, eliminating costly dies.

The lack of toolroom labour is a serious drawback to early production and it may be necessary to sub-contract tool and jig manufacture. The value of a lofting system cannot be over stressed as it enables a high degree of interchangeability to be achieved. Wider use of standardised components would be desirable but the difficulties of application to aircraft production are pronounced. To some extent it is possible to alleviate the jig production situation by employing the experimental shop in building prototype jigs which, subsequently, may be used for production machines.

The time taken to make the prototype components will be of the order of nine months because of the lack of tools, but on production aircraft this may be reduced to four months by using batch production methods. Assembly of the prototype in the experimental shop requires 200 to 300 man years and in an establishment of average size three to three and a half years will be needed for completion.

After this, there will be a period of testing involving one month of ground tests and three months of air testing before the aircraft is subjected to six months' of official tests. If the aircraft is accepted and an order is given, the first production aircraft will be 18 months in building and it is unlikely that a batch will see squadron service for a further nine months.

Thus the evolution of a new aircraft will require some five to seven years from specification to regular delivery to the squadrons. This influences profoundly the selling price of the aircraft when its cost is added to the production costs. In wartime, the actual expenditure of money may be of secondary importance but time and labour are vital in order to preserve a measure of technical superiority over the enemy. In peacetime, the selling price may attain prohibitive proportions if this development cost has to be met with a limited production and an uncertain market, as is usually the case. Hence it is apparent that the question of the time scale is vitally important to the Aircraft Industry under all conditions. The elimination of wasted hours in any aspect of the project will reap large dividends and indeed, may be essential for the survival of the Industry in its present form.

THE ROYAL AERONAUTICAL SOCIETY
4 HAMILTON PLACE, PICCADILLY, LONDON, W.1. GROSVENOR 3515-9

NOTICES JANUARY 1950

NEW YEAR

The President and Council and the Staff extend to all members at home and overseas their best wishes for the year 1950.

CONTENTS OF JANUARY JOURNAL

Note on Repeated Loading Tests on Components and Complete Structures, H. L. Cox, M.A., F.R.Ae.S., and E. P. Coleman.
Directionality of Wrought Light Alloy Materials, I. L. G. Baillie, B.Sc., G.I.Mech.E.
Resistance-Wire Strain Gauges, J. G. Strong, B.Sc., A.C.G.I., A.F.R.Ae.S.
Summary of the Activities of the Society, January-December 1949.
Review.
Correspondence.

The Council have set aside an annual sum of £250 for the award of premiums for papers published in the Journal and hope that members and non-members of the Society will contribute papers on their own special subjects.

THE AERONAUTICAL QUARTERLY

Part IV of " The Aeronautical Quarterly " will be ready towards the end of February.

Copies of Parts I, II and III are still available and may be obtained from the offices of the Society, 4 Hamilton Place, W.1, at 7s. 9d. each to members of the Society, post paid, or 10s. 3d. each to non-members, post paid.

The contents of Part III are:—

Surging of Axial Compressors	H. Pearson and T. Bowmer
Strain Measurement by X-Ray Diffraction Methods	G. B. Greenough
Buckling of a Longitudinally Stiffened Flat Panel	H. L. Cox and J. R. Riddell
Approximate Calculation of the Laminar Boundary Layer	B. Thwaites

The contents of Part II are:—

Displacements of a Linear Elastic System under a Given Transient Load	D. Williams
Skin Friction in the Laminar Boundary Layer in Compressible Flow	A. D. Young
The Measurement of Gas Turbine Combustion Efficiency by Gas Analysis	L. J. Richards and J. C. Street
A Simplified Theory of " Simple Waves "	A. Ghaffari

The contents of Part I are:—

Control Reversal Effects on Swept-Back Wings	H. Templeton
Calculation of Downwash Behind a Supersonic Wing ..	G. N. Ward
Estimation of the Effects of a Parameter Change on the Roots of Stability Equations	K. Mitchell

Flutter of Systems with Many Freedoms	W. J. Duncan
Note on Propeller-Turbine Reduction Methods	E. C. Pike
Determination of the Drag of Jet-Propelled Aircraft in Flight	G. W. Trevelyan and D. R. Blundell
Notes on the Linear Theory of Incompressible Flow Round Symmetrical Swept-back Wings at Zero Lift	F. Ursell

The special attention of members is drawn to the fact that a strictly limited edition only of " The Aeronautical Quarterly " is printed and numbers cannot be reprinted in any circumstances.

THE BRANCHES OF THE SOCIETY

In February 1950 the oldest Branch of the Society, Coventry, will have been formed for 24 years.

There are now 19 Branches in Great Britain. The total membership is over 4,000, of which 1,400 are members of the Society. Some idea of the extent of the work of the Branches can be obtained from the fact that in 1949 over 180 lectures and 50 visits were organised.

Through its Branches the Society reaches out to a much wider field of membership than is possible through main Society membership alone. No qualifications are required for Branch Membership, only an enthusiasm for Aeronautics and the desire to take part in the discussions on the various technical aspects of Aeronautics. Each Branch has its nucleus of main Society members and a larger body of Branch members.

The Branch membership varies in number from as small as 80 members to over 500.

The Council does not take the initiative in the formation of Branches, but has always held the view that for a Branch in any area to be a success the enthusiasm and the demand for the Branch must be local as all Branches, when formed, are autonomous and although assisted where necessary from Headquarters, manage their own affairs.

The Council has always tried to encourage the Society's members to take part in local Branch affairs. In 1945 it agreed to pay the Branch subscriptions for all Society members who are active members of their local Branch. In the Branches the Society members have a great opportunity to further the objects of the Society by passing on their knowledge of Aeronautics to other people.

Before a new Branch is formed approval has to be obtained from the Council. A request for formation must be signed by voting members of the Society. The Council lays down the condition that before any such request is sent to it a meeting should be called in the area concerned at which at least 20 people are present and that this meeting should pass a formal resolution requesting the formation of the Branch. Before approval is granted the Council ensures that five main conditions governing the Branches should be obeyed:—

1. The Branch shall not be connected by name or fact with any particular firm and its membership shall not be restricted to employment by one firm.
2. The Branch shall be controlled in a democratic manner and the affairs of the Branch shall be in the hands of its members.
3. The objects of the Branch shall be the formation of a nucleus of informed technical opinion on technical matters and the furtherance of the objects of the Royal Aeronautical Society.
4. Membership shall be open to all persons over 16 years of age.
5. The Society shall incur no liability through the formation or carrying on of the Branch.

All assistance is given from Headquarters in getting the new Branch under way and the success of the scheme is demonstrated by the fact that in the past 14 years only one Branch has been closed down, and this was inevitable as the Aircraft Industry in the locality moved to another centre.

The Branches look to the Society members in their area for support and any member of the Society wishing to join a Branch should write to the local Secretary asking for details.

UNIVERSITY COLLEGE, SOUTHAMPTON

Applications are invited for appointment to the Chair of Aeronautical Engineering —a new Chair which is being founded as from the 1st October 1950.

The appointment is a wholetime one and the Professor will be *ex-officio* a member of Senate and of the Engineering Faculty Board.

It will be his duty to attend to such administration and teaching as is required by the scheme of study of the College in conformity with the general regulations from time to time laid down by Senate, and to do all in his power to promote the advancement of the study of his subject, and the welfare and corporate life of the College.

He will be expected to engage in Research, and to further the prosecution of Research within his Department.

The salary of the Chair of Aeronautical Engineering will be in the range £1,600-£1,900 per annum, according to qualifications and experience. A child allowance for each dependent child will be paid in addition until the end of the child's period of full-time education.

The Professor will be required, as a condition of the appointment, to join the Federated Superannuation System for Universities, to which he will contribute 5 per cent. of his salary, and the College Council, on its side, will contribute an amount equal to 10 per cent. of his salary.

The tenure of office will be subject to a full term's notice on either side, the Summer Vacation to be reckoned as a term.

The staff of the Department covering Civil, Mechanical, Electrical and Aeronautical Engineering, in addition to two Professors, consists of three Senior Lecturers, 11 Lecturers, five Assistant Lecturers and one Demonstrator. The number of full-time University students in the Department will normally be 200, of whom some 25 are likely to specialise in Aeronautical Engineering. The College also provides the Senior Technical instruction for the area, and some advanced teaching in Aeronautical Engineering is required for a number of part-time students.

The candidate selected will be required to enter upon his duties on the 1st October 1950.

Applications (15 copies) accompanied by two recent testimonials (15 copies), together with the names of two further referees, must be received by the Registrar not later than 31*st January* 1950.

DEFENCE SERVICES RESEARCH FACILITIES COMMITTEE

The Defence Services Research Facilities Committee was set up by the Royal Society in 1948 to enlist the help of the Services on behalf of scientific workers. The terms of reference of the Committee are:—

> "To consider proposals for the use of Service facilities and personnel for assisting scientific research, and to make recommendations to the Council of the Royal Society, the Lords Commissioners of the Admiralty, the Army Council, the Air Council and the Minister of Supply."

Five panels were established to consider applications for help on the following:—

Panel A. Submarine Gravity Measurements.
,, B. Surplus Explosives.
,, C. Magnetic Survey.
,, D. Aerial Photography.
,, E. Scientific Expeditions.

The Defence Services have been most co-operative.

Scientists wishing to submit proposals for consideration by the Committee should communicate their suggestions in the first instance to the Assistant Secretary of the Royal Society, Burlington House, London, W.1.

MEMBERS' NEW APPOINTMENTS

J. P. Jeffcock, O.B.E., M.I.E.E., *Fellow*—Commercial Manager, Equipment Division, Mullard Electronic Products Ltd., Director, Mullard Equipments Ltd.

Air Vice-Marshal A. C. Collier, *Associate Fellow*—Board of D. Napier & Son Ltd.

Air Vice-Marshal A. Ferrier, *Fellow*—I.C.A.O. Assistant Secretary-General for Air Navigation.

H. Sammons, M.I.MechE., *Fellow*—Managing Director, D. Napier & Son Ltd.

ASSOCIATE FELLOWSHIP EXAMINATIONS

Candidates are reminded that entries for the May 1950 examination close on 31st January 1950. Entry forms may be obtained on application to the Secretary.

LECTURES—SPRING 1950

MAIN LECTURES

(To be held at 6 p.m. at the Institution of Civil Engineers, Gt. George Street, S.W.1, unless otherwise stated. Tea will be served at 5.30 p.m.)

Thursday, 9th February 1950—The Producing of a Prototype Aircraft, C. T. Wilkins, A.F.R.Ae.S.

Thursday, 16th March 1950—Air Survey, Group Capt. F. C. V. Laws, C.B., C.B.E.

Thursday, 30th March 1950—Modern Methods of Testing Aero-Engines and Power Plants, A. C. Lovesey, O.B.E., B.Sc., F.R.Ae.S.

Thursday, 13th April 1950—The Berlin Air Lift, Air Commodore J. W. F. Merer, C.B.

Thursday, 27th April 1950—AT MANCHESTER—Recent Developments in High Speed Research in the Aerodynamics Division of the N.P.L., J. A. Beavan, M.A.(Cantab), A.F.R.Ae.S., and D. Holder—**at the Chemistry Lecture Theatre, Manchester University, at 6.30 p.m.**

Thursday, 4th May 1950—3rd LOUIS BLERIOT LECTURE—IN PARIS, Sir Frederick Handley Page, C.B.E., F.I.Ae.S., Hon.F.R.Ae.S.

Thursday, 25th May 1950—38th WILBUR WRIGHT MEMORIAL LECTURE, Sir Richard Fairey, M.B.E., F.R.Ae.S.

SECTION LECTURES

(To be held at 7 p.m. in the Library, 4 Hamilton Place, London, W.1, unless otherwise stated.)

Thursday, 19th January 1950—At 5.30 p.m. (Tea 5 p.m.)—Joint Section Lecture with the Acoustics Group of the Physical Society—Acoustical Aspects of Recent Aerodynamic Research.

Short Lectures on: Supersonic Noise of Aircraft, N. Fleming, M.A.
Noise and Vibration in Wind Tunnels, H. B. Squire, M.A., F.R.Ae.S.
Periodic Boundary Layers, Dr. E. G. Richardson, B.A., D.Sc.
Acoustic Analogues in Calculating Supersonic Resistance, A. Robinson, M.Sc., A.F.R.Ae.S.

Tuesday, 31st January 1950—Further Problems of Aircraft Stressing, J. H. Argyris, A.F.R.Ae.S.

Tuesday, 14th February 1950—Prototype Testing of Aircraft, D. R. H. Dickinson, A.F.R.Ae.S.

Tuesday, 21st February 1950—Air Intake Design for High Speed Aircraft, Dr. J. Seddon, B.Sc.

Tuesday, 21st March 1950—Boundary Layer at High Speeds, A. D. Young, M.A., A.F.R.Ae.S.

Tuesday, 25th April 1950—Flight Refuelling and the Problem of Range, C. H. Latimer Needham, M.Sc., F.R.Ae.S.

BRANCH LECTURES

BELFAST BRANCH

Tuesday, 24th January 1950—Recent Developments in Aircraft Production Engineering, Professor J. V. Connolly, B.Eng., F.R.Ae.S.

Tuesday, 14th March 1950—Problems of High Speed Flight, H. Davies, M.Sc., F.R.Ae.S.

Tuesday, 4th April 1950—Annual General Meeting.
In the Central Hall, College of Technology, Belfast, at 7 p.m.

BIRMINGHAM BRANCH

Friday, 27th January 1950—Inter-Planetry Flight and Rocket Propulsion, A. V. Cleaver, A.R.Ae.S.

Friday, 24th February 1950—A Chat on Aero-Engines, Air Commodore F. R. Banks, C.B., F.R.Ae.S.

Friday, 31st March 1950—President's Night, Dr. S. C. Redshaw, F.R.Ae.S.

Friday, 21st April 1950—Annual General Meeting and Smoking Concert—*at the White Horse Hotel.*
Meetings are usually held at the Birmingham Chamber of Commerce at 7.30 p.m.

BRISTOL BRANCH

Monday, 16th January 1950—Operational Factors Affecting the Design of Future Civil Air Transport Aircraft, C. Dykes, M.A., A.F.R.Ae.S.

Monday, 30th January 1950—Bird Flight, Professor H. B. Passat.

Monday, 13th February 1950—Aerial Photography, Group Captain F. C. V. Laws, C.B., C.B.E.

Monday, 27th February 1950—The Role of Aircraft in Future Warfare, Air Marshal Sir Robert Saundby, K.B.E., C.B., M.C., D.F.C., A.F.C.

Monday, 13th March 1950—Junior Members' Papers Competition.

Monday, 27th March 1950—Gliding, A. H. Yates, Esq., B.Sc., A.F.R.Ae.S.

Wednesday, 5th April 1950—Recent Developments in Aircraft Production and Engineering, Professor J. V. Connolly, B.E., A.F.R.Ae.S.

Monday, 24th April 1950—Annual General Meeting and Film Show.
In the Conference Room, Bristol Aeroplane Co. Ltd., Filton House, at 6 p.m.

BROUGH BRANCH

Wednesday, 11th January 1950—Members' Lecturette Night.

Wednesday, 8th February 1950—Rocket Propulsion and Interplanetary Flight, A. V. Cleaver, A.R.Ae.S.

Wednesday, 5th April 1950—Design Problems of the Flying Boat, H. Knowler, F.R.Ae.S., A.M.I.C.E.

In the Lecture Hall, Electricity Showrooms, Ferensway, Hull, at **7.30 p.m.** Admission by ticket only, because of limited accommodation.

COVENTRY BRANCH

Wednesday, 18th January 1950—High Speed Flight, A. D. Young, A.F.R.Ae.S.

Wednesday, 15th February 1950—The Ghost Engine Installation of the Comet, W. T. Winter.

Wednesday, 15th March 1950—Flying Boats, H. Knowler, F.R.Ae.S.

Wednesday, 19th April 1950—Annual General Meeting and Films.

All lectures will be held in the Trinity Hall, Ford Street (near Pool Meadow) at 7.30 p.m. Membership cards to be shown at all lectures.

GLASGOW BRANCH

Tuesday, 24th January 1950—Debate—This House is of the Opinion that Civil Aviation is a Luxury.

Tuesday, 21st February 1950—Lecturettes.

Thursday, 23rd March 1950—Fuel Consumption, J. Leggatt, Student R.Ae.S.

At the St. Enoch Hotel, Glasgow, at **7.30** p.m.

GLOUCESTER AND CHELTENHAM BRANCH

Thursday, 12th January 1950—*at Cheltenham*—Recent Developments in Aircraft Production Engineering, Professor J. V. Connolly, B.Eng., F.R.Ae.S.

Wednesday, 8th February 1950—*at Gloucester*—The Probable Role and Influence of Aircraft in Future Warfare, Air Marshal Sir Robert Saundby, K.B.E., C.B., M.C., D.F.C., A.F.C.

Wednesday, 29th March 1950—*at Gloucester*—Materials of Aircraft Construction and Material Processing, Dr. H. Sutton, D.Sc., F.R.Ae.S., F.I.M.

Thursday, 20th April 1950—*at Cheltenham*—Annual General Meeting.

Gloucester Meetings (Wednesdays) are held in the Wheatstone Hall, City Library, Brunswick Road, at **7.30** p.m.

Cheltenham Meetings (Thursdays) are held in the Empire Hall, North Street, at **7.30** p.m.

ISLE OF WIGHT BRANCH

Thursday, 12th January 1950—Discussion Evening. Control Systems.

Thursday, 26th January 1950—Human Limitation to High Speed, High Altitude Flight, Squadron Leader J. S. Howitt.

Thursday, 23rd February 1950—One Thousand Miles an Hour, Professor G. T. R. Hill.

Thursday, 23rd February 1950—The Application of Propeller Turbines to Civil Airliners, E. J. Richards, M.A., B.Sc., A.F.R.Ae.S.

Thursday, 9th March 1950—High Speed Research, J. D. Derry.

Thursday, 23rd March 1950—Gliding, P. A. Wills, C.B.E.

In the Saunders-Roe Sports and Social Club at **6** p.m.

MANCHESTER BRANCH

Wednesday, 25th January 1950—Civil Air Transport, Present and Future, P. G. Masefield, Esq., M.A., F.R.Ae.S.

Thursday, 2nd February 1950—The role of Aircraft in War and their Probable Influence on the Future, Air Marshal Sir Robert Saundby, K.B.E., C.B., M.C., D.F.C., A.F.C.—*at the Engineers' Club, 17 Albert Square, Manchester.*

Wednesday, 22nd March 1950—Accident Investigation, Air Commodore Vernon S. Brown, C.B., O.B.E., M.A., F.R.Ae.S.

Meetings are held in the Reynolds Hall College of Technology unless otherwise stated.

PORTSMOUTH BRANCH

Friday, 13th January 1950—Accident Investigation, Air Commodore Vernon S. Brown, C.B., O.B.E., M.A., F.R.Ae.S.

Friday, 10th February 1950—Journey to South Africa by Solent Flying-Boat, Geoffrey Dorman, A.R.Ae.S.

Friday, 10th March 1950—Design Problems of Large Flying Boats, H. Knowler, F.R.Ae.S.

Friday, 7th April 1950—The Probable Role and Influence of Aircraft in Future Warfare, Air Marshal Sir Robert Saundby, K.B.E., C.B., M.C., D.F.C., A.F.C.

In the Lecture Room, Central Library, at 7 p.m.

WEYBRIDGE BRANCH

Wednesday, 11th January 1950—Brains Trust.

Friday, 20th January 1950—Annual Dance—*at St. George's Hill Tennis Club.*

Wednesday, 8th February 1950—The Aerodynamic Consequences of Flying High and Fast, W. G. A. Perring, C.B., F.R.Ae.S., A.M.I.N.A.

Wednesday, 1st March 1950—Do Scientists Know Anything? C. G. Grey, *Founder Member* R.Ae.S.

Wednesday, 22nd March 1950—Junior Prize Lecture, Branch Members.

Wednesday, 31st May 1950—Annual General Meeting.

At Vickers-Armstrongs Ltd., Weybridge Works, at 6 p.m., unless previous notice is given.

GRADUATES' AND STUDENT SECTION

Thursday, 23rd February 1950—Some Problems of Heat Transfer, W. R. Shapey, B.Sc., Grad.R.Ae.S., and J. Rivers, Grad.R.Ae.S.

Wednesday, 1st March 1950—A Joint Meeting with the Graduate Sections of the Institution of Electrical Engineers and the Institution of Mechanical Engineers. Some Engineering Problems of Aircraft Design.

This meeting will be held at 7 p.m. at the Institution of Mechanical Engineers, Storeys Gate, S.W.1.

Tuesday, 7th March 1950—Gas Turbine Installation, J. C. Wallin, B.Sc., A.F.R.Ae.S.

Tuesday, 28th March 1950—Undercarriage Design and Testing, G. S. Cranwell, Grad.R.Ae.S.

Tuesday, 18th April 1950—A Discussion Evening on The Training of Aeronautical Engineers. Chairman: Marcus Langley, F.R.Ae.S.

All members of the Society are particularly invited to take part in this discussion.

Meetings are held in the Library, 4 Hamilton Place, W.1, at 7.30 p.m., unless otherwise stated.

ANNUAL SUBSCRIPTIONS

Members are reminded that their annual subscriptions became due on 1st January 1950. The rates are:—

	Home	Abroad
	£ s. d.	£ s. d.
Fellows	5 5 0	4 4 0
Associate Fellows	4 4 0	3 3 0
*Associates	3 3 0	3 3 0
Graduates (aged under 26)	2 2 0	2 2 0
Graduates (aged 26 and over)	2 12 6	2 12 6
Students (aged under 21)	1 1 0	1 1 0
Students (aged 21 and over)	1 11 6	1 11 6
Companions	3 3 0	3 3 0
Founder Members	2 2 0	2 2 0

* Any Associate elected before 1st October 1947 may, if he wishes, elect not to receive the Journal, and in this case his subscription will be reduced by £1 1s. 0d. to £2 2s. 0d.

It will avoid delay and confusion if members, when sending remittances for subscriptions, will state their names clearly and give their addresses and grades of membership.

Remittances should be made payable to the Royal Aeronautical Society.

CHANGE OF ADDRESS

To assist in keeping the records of members correct and up to date the Secretary will be glad if all members will notify him as soon as possible of changes of address.

When notifying changes please give the following particulars:—

Name (in block letters).

Grade of membership.

New address (in block letters).

Old address.

Changes of address must be received *before the 15th of the month* in order to be effective for the Journal for the following month.

ELECTIONS

The following is a list of new members and transfers of membership of the Society:—

Associate Fellows

Arthur James Almond, Henri Amiot, Eric Nigel Atkey (from Graduate), Thomas Webster Bagshaw (from Graduate), William Anthony Cann, John Frederick Cannell (from Graduate), Eric Neville Crabbe (from Student), Joseph Crane, Maurice Cecil Curties (from Graduate), Austin Roy Fox (from Graduate), William Gillespie, Robert John Griggs (from Graduate), Thomas Allan Harvie (from Graduate), Ernest Hobart (from Student), Leslie Howarth, Norman Parry Hughes (from Associate), Louis Kahn, John William Langworthy (from Graduate), Thomas Dane Martin, Norman Alfred Miller, Leslie Sydney Dennis Morley (from Student), Douglas Edward Pay, Arthur Charles Samuel Pindar, Hilary John Silvanus Pinsent (from Student), Gordon Albert Pullinger (from Student), Desmond Leonard Rendell (from Associate), Evers Turner Buchanan Smith (from Graduate), Wilfred Smith, Raymond Spencer Soloman, Douglas Oliver Spratt (from Associate), Donald Lee Taylor (from Associate), Maurice Vernon Taylor, John Richard Thirkettle (from Graduate), Bryan Thwaites, Ernest Toner, Cameron Arthur Turner, Philip Edward Tweed, Allen Chivers Walker, Hubert Beresford Walker (from Graduate), Francis John Powell Wood, William Glanville Woodward (from Associate), John Wotton.

Associates

Ian Darling Anderson, Eldred Ashton (from Student), Charles Herbert Baldwin, Arthur Edwin Briggs, Alan Howard Brooks, Thomas Malcolm Grahame Bury, David Albert Ronald Carter, Wilfred Ernest Casley, Thomas Edward Davis, Edmund Frank John Gericke (from Companion), Stuart George Hall, Harry Heap, Ronald Frederick Hill, Arthur Frederick Hindell, Alan Alfred Hughes, Walter James Arthur Humphries, Albert Victor Parker, Kenneth Arthur Steel, Jean Taton, Guy West Underwood, Geoffrey Leonard Freeman Welham.

Graduates

Eric Bertram Alexander, Phillip Hayden Baldwin, Stanley Michael Baldwin, Peter John Bell (from Student), Ronald Vincent Belvoir (from Student), Alec Tom Binding, Robert Alexander Ross Black, Brian John Bleaney, Thomas Brindley Booth (from Student), Peter Bradshaw (from Student), Peter Brett (from Student), Reginald Arthur Bridgeman (from Student), Alan James Bullock, Christopher Edwin Burrows (from Student), Alan Henry Butler, John Burton Harris Campbell, Alfred George Campion, Edward Christopher Carter (from Student), Anthony Lambert Cole (from Student), John Robert Collingbourne, John Stuart Collins, Douglas Colin Cox, John Perran Curry (from Student), Richard John Davies, Clifford Henry Davis (from Student), Frederick Walter Dee, Ralph Murch Denning (from Student), William Ernest Digweed (from Student), Donald Stephen Dugdale (from Student), Ronald George Edwards, Robert Charles Eeles, John Derek Ellis, Albert David Fowler, George Edward Fowler, John William Fozard, Peter Lawrence Edward Gallimore (from Student), Donald Ganson, Nilansu Ghose, Richard Wilfred Goddard, Alan John Goodwin, Ronald Grey, Dennis Victor Hadnutt, George Thomas Hayes, Alan George Hobbs (from Student), Maurice Donald Hodges (from Student), Rex Richard Howlett (from Student), Desmond James (from Student), Donald Joseph, John Robert Denis Kenward (from Student), Edward Geoffrey Lewis (from Student), Ernest Arthur Lewis, Gordon Walter Little, Robert Angus Mackay, Charles Algernon Mathias, Charles William May, Spencer Davidson Meston (from Student); Thomas John Methven, Jeffrey Nicholas Montgomery (from Student), Brian Ronald Morris (from Student), Arthur Owen, Terence Clive Owens, John Henry Paterson, Brian William Plenderleith (from Student), Janusz Stanislaw Przemieniecki, John Leonard Raynes (from Student), Ronald Albert James Regan; Brian Reynolds, Gerald Edward Harry Rice, Anthony Max Richards, Roger Gordon Richards (from Student), Arnold Rose, William Colin Ruler, James Beat Scott, Geoffrey Gordon Semark (from Student), Bryan Charles Smith (from Student), Neil Hickman Stewart, David Thomas John Stops (from Student), James Donald Storer, John Hunter Taylor, Desmond Arthur Treadgold (from Student), Donald William Trebley, Geoffrey Michael Trewinnard (from Student), James Gillette Try (from Student), Michael Henry Lewin Waters (from Student), Denis Edward Williams, Geoffrey Edward Williams (from Student), Robert Hugh Williams (from Student), William Gerald Williams, Paul Heinz Walter Wolff (from Student).

Students

Michael John Gerry Ash, Roger Frederick Back; Arthur Sidwell Bennett; Dennis Bernard Black, Gobinda Chandra Chatterjee, Deryck Walter Childs, George Allan Collins, Douglas Henry Cook, Trevor Storr Davies, Barry Vincent Davis, Geoffrey Michael Deacon, Kenneth Deegan, Dakshina Ranjan Dutt, Friedericke Englander, Hamid Farooq, Montague Samuel Edmund Gumbley, Jeffery Philip Hawkins, Ian Douglas Huntley, Matthew Alexander Hutchison, David John Leahy, Brian Alexander MacDowel, Ronald Conway Margetts, Hugh Somerton Mettam, Raymond John Miskin, Leslie Frank Nicholls, John Jacob Rudolf, Geoffrey Arthur Clayden Searle, Norman Woodhead Seccombe, David Shellard, John Hyslop Steele, Brian Rodney Townsend, Neville Upton.

Companions

Lawrence Kershaw Lord (from Student), Ralph Thomas Sage, C. R. Rajagpal.

ADDITIONS TO THE LIBRARY

Pamphlets in italics. Books marked * or ** may not be taken out on loan.

A.b.87—Theoretical Hydrodynamics. L. M. Milne-Thomson. Second Edition. Macmillan. 1949.

A.b.88—Dynamics of Real Fluids. E. G. Richardson. Edward Arnold. 1949.

A.c.22—Heat Transfer and Fluid Mechanics Institute. American Society of Mechanical Engineers. 1949.

B.f.107—Birds in Action. E. Hosking and C. Newberry. Collins. 1949.

*B.g.157—Observer's Book of Aircraft. J. Lawrence. F. Warne. 1949.

D.a.A.46—Transatlantic Passenger Traffic. Civil Aeronautics Board. 1949.

D.b.282—Airline Traffic Procedures. G. Kropf. McGraw Hill. 1949.

E.c.37—Strength of Metal Aircraft Elements. Aircraft Committee. U.S. Government Printing Office. 1949.

E.c.40—Photoelasticity. H. T. Jessop and F. C. Harris. Cleaver-Hume Press. 1949.

EE.h.57—Elements of Internal Combustion Turbine Theory. H. I. Adams. Cambridge University Press. 1949.

F.a.9—Military Economics of Refuelling. C. H. Latimer-Needham. Flight Refuelling Ltd., Littlehampton. 1949.

I.c.45—Extrapolation, Interpolation and Smoothing of Stationary Time Series. N. Wiener. Wiley & Sons. 1949.

L.a.57—Learning to Fly. B. A. Shields. Pitmans, New York. 1949.

L.b.45—Private Flying (To-day and To-morrow). W. T. Piper and D. Duffin. Pitmans, New York. 1949.

L.b.46—Private Pilot's Handbook. A. G. Norwood. Second Edition. Pitmans, New York. 1949.

R.c.298—The Manly Engine. C. M. Manly. Society of Automotive Engineers. 1948.

S.b.155—Wings of the Phœnix; Official Story of the Air War in Burma. Air Ministry. H.M.S.O. 1949.

S.d.102—War in Three Dimensions. E. J. Kingston-McCloughry. Jonathan Cape. 1949.

N.A.C.A. Technical Notes

1938—*Mechanisms of failure of high nickel-alloy turbojet combustion liners. J. W. Weeton.*

1943—*Theoretical relations between the stability derivatives of a wing in direct and in reverse supersonic flow. S. M. Harmon.*

1948—*Investigation of bonding between metals and ceramics. I—Nickel, cobalt, iron, or chromium with boron carbide. H. J. Hamjian and W. G. Lidman.*

1951—*Method of determining conditions of maximum efficiency of an independent turbine-propeller combination. M. F. Heidmann.*

1952—*Analytical method for determining transmission and absorption of time-dependent radiation through thick absorbers. II—Source intensity, time-dependent. G. Allen.*

1953—*On the theory of oscillating airfoils of finite span in subsonic compressible flow. E. Reissner.*

1954—*Experimental and theoretical distribution of flow produced by inlet guide vanes of an axial-flow compressor. H. B. Finger, H. J. Schum and H. A. Bucker, Jr.*

1956—*Equilibrium operating performance of axial-flow turbojet engines by means of idealised analysis. J. S. Sanders and E. C. Chapin.*

1957—*Direct method of design and stress analysis of rotating disks with temperature gradient. S. S. Manson.*

1960—*An evaluation of the use of ground radar for avoiding severe turbulence associated with thunderstorms. J. K. Thompson and V. W. Lipscomb.*

N.A.C.A. Technical Memoranda

1239—*Two-dimensional motion of a gas at large supersonic velocities. S. V. Falkovich.*
1200—*Measurement of oil-film pressures in journal bearings under constant and variable loads. A. Bucke and W. Rolli.*
1236—*A class of de Laval nozzles. S. V. Falkovich.*
1245—*Lift force of an arrow-shaped wing. M. I. Gurevich.*

N.A.C.A. Reports

868—*Summary of lateral-control research. Langley Research Staff.*
888—*A theory of unstaggered airfoil cascades in compressible flow. R. A. Spurr and J. H. Allen.*
910—*Summary of drag characteristics of practical-construction wing sections. J. H. Quinn, Jr.*
912—*The interdependence of various types of autoignition and knock. H. L. Olsen and C. D. Miller.*
913—*Experiments on stability of bunsen-burner flames for turbulent flow. L. M. Bollinger and D. T. Williams.*
916—*Correlation of the drag characteristics of a typical pursuit airplane obtained from high-speed wind-tunnel and flight tests. J. M. Nissen, B. L. Gadeburg and W. T. Hamilton.*

A.R.C. Reports and Memoranda

2306—*Design of propeller-turbine combinations. A. B. Haines.*
2326—*Low-speed model tests on the effect of nose and gap details on elevator characteristics. J. E. Adamson and E. G. Barnes.*
2426—*A solution of the laminar boundary-layer equation for retarded flow. D. R. Hartree.*
2427—*The solution of the equations of the laminar boundary layer for Schubauer's observed pressure distribution for an elliptic cylinder. D. R. Hartree.*

National Research Council of Canada

MM.213—*N.R.L. hydraulic static testing apparatus. J. K. Haviland and G. F. W. McCaffrey.*
MA.214—*Two-dimensional hinge moment calculations. P. Mandl.*
MA.216—*Wind tunnel interference on rolling moment of a rotating wing. P. Mandl and J. R. Pounder.*

Nationaal Luchtvaartlaboratorium, Amsterdam

F.35—*A one parameter method for the calculation of laminar boundary layers. R. Timmam.*

J. LAURENCE PRITCHARD,
Secretary.

The Lewes Press (Wightman & Co. Ltd.), Friars Walk, Lewes, Sussex.

MESSIER

HYDRAULIC ACCUMULATOR

The Messier type of cylindrical accumulator with separator piston is a highly refined design of extreme simplicity. Lighter than competitive designs including spherical types, it is available in a full range of capacities for two standard pressures — 2500 and 4000 lb. sq. in.

BRITISH MESSIER LIMITED CHELTENHAM ROAD EAST GLOUCESTER TELEPHONE: CHURCHDOWN 3241

君現準備簽訂合約否？

"Yes— I'll fly at once!"

Businessmen with global interests depend on regular Speedbird service *to all six continents*. They know that a decision made today in Hong Kong, for example, may mean a conference there next week. They know, too, that 175,000 miles of B.O.A.C. routes to 51 countries make this kind of prompt action possible. They fly without delay, swiftly and in comfort—on *one ticket* all the way. These same advantages can be yours, too ! Complimentary meals served en route; no tips or extras. It's part of B.O.A.C.'s 31-year-old tradition of Speedbird service and experience.

B.O.A.C. TAKES GOOD CARE OF YOU

. . . WITH MILLION-MILE PILOTS

BOOK NOW ! *No charge for advice, information or bookings by Speedbird to all six continents at your local B.O.A.C. Appointed Agent or B.O.A.C., Airways Terminal, Buckingham Palace Rd., London, S.W.1. Telephone: VICtoria 2323.*

FLY BRITISH BY B·O·A·C

BRITISH OVERSEAS AIRWAYS CORPORATION IN ASSOCIATION WITH QANTAS EMPIRE AIRWAYS LIMITED, SOUTH AFRICAN AIRWAYS & TASMAN EMPIRE AIRWAYS LIMITED

WORLD-WIDE AUTHORITIES ... *ON DESIGN, OPERATION & PRODUCTION OF ALL TYPES OF AIRCRAFT*

FLIGHT (weekly) provides the most authentic information on world aeronautical affairs. It covers every aspect of development and progress in aircraft and power unit design and operation. AIRCRAFT PRODUCTION (monthly) is the journal of the aircraft manufacturing industry, specialising in tools and works production processes. The editorial staffs of each journal are experts in their own particular sphere, with unrivalled experience and resources. Both journals serve the interests of all concerned with the future progress of British Aviation. Technical information is supplemented by brilliant functional drawings. Circulation is world-wide. Annual subscriptions (Home and Overseas) FLIGHT £3.1.0, AIRCRAFT PRODUCTION £1.14.6.

Published in conjunction with these journals. FLIGHT HANDBOOK (212 pages, 7/6 net) is essentially a manual for the student, whilst GAS TURBINES AND JET PROPULSION (272 pages, 12/6 net) by G. Geoffrey Smith, has been widely adopted as the standard textbook on the subject by Universities, Technical Institutions and Training Centres everywhere.

ASSOCIATED ILIFFE PUBLICATIONS

DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1. WATERLOO 3333 (60 LINES)

Choose

YOUR HOLIDAY PLACE

Travel without trouble by Australia's International Airline—famous for 28 years of service. On the ground and in the air, Qantas makes your personal comfort a paramount responsibility.

Ask your travel agent for details.

Come abroad to see the World!

SINGAPORE

ROME

SYDNEY

NORFOLK Is.

NEW GUINEA

CAIRO

INDIA

LORD HOWE Is.

NOUMEA

SUVA

PAKISTAN

Fly there

WITH

QANTAS EMPIRE AIRWAYS
Australia's International Airline

Q·E·A

IN ASSOCIATION WITH BRITISH OVERSEAS AIRWAYS CORPORATION

The new

R.A.F. QUARTERLY

(AND COMMONWEALTH AIR FORCES JOURNAL)

now **3/6**

THIS is your Journal. Unique in its appeal and scope and in the authoritative nature of its articles. It is a valuable and much needed link between Units all over the world, and between members of the Royal Air Force, serving and retired.

Profusely illustrated, R.A.F. Quarterly is packed with interest for all who are interested in the R.A.F. :—

R.A.F. life to-day : R.A.F. in Parliament : R.A.F. News and Views : R.A.F. Sport : R.A.F. Biographies, News of Dominions Air Forces : Discussion Forum : Appointments, etc.

Now only **3/6**, R.A.F. Quarterly is the best value of its kind and it is rapidly increasing its circulation amongst those who wish to keep abreast with the development of the Service.

Make sure of your copy now by ordering from your bookseller, or order direct from the publishers :

GALE & POLDEN, LTD

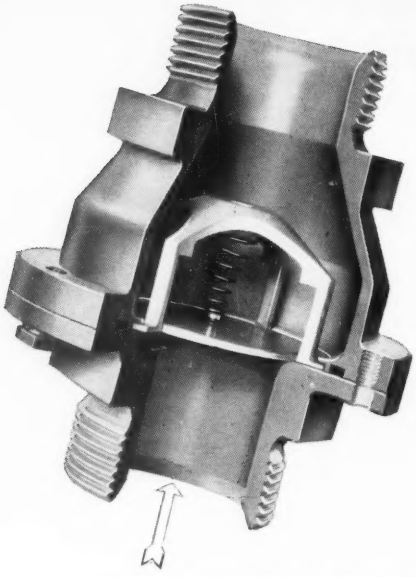
Ideal House, Argyll St., Oxford Circus, London W1. *Phone* : GERard 4171

"What colour is petrol?"

"As far as I'm concerned — and my job is fuelling aircraft — petrol is green, blue or water white. Depends what you want it for. 100/130 Grade is green — for big aircraft like the Constellation or the Solent. 91/98 Grade is blue. 73 Octane is water white — for Rapides, for example, and most private aircraft." Petrol colouring is a double-check on safety, another facet of the Shell-B.P. Aviation Service — which maintains a 24 hour, all-the-year-round, stand-to at the chief British airports. At nearly 30 British aerodromes the Service is available — to help everyone from a Skymaster Captain who wants 3000 gallons (green) to the private owner who wants 10 gallons (water white).

Shell-BP Aviation Service

Shell-Mex & BP Ltd., Shell-Mex House, Strand, WC2, Distributors in the UK for the Shell & Anglo Iranian Groups



Vickers Spring-loaded Non-return Valve

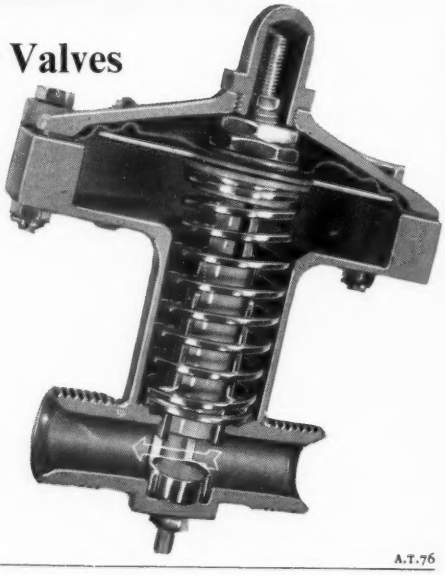
The Spring-loaded type A.5179 valve, for fuel and oil systems, is sealed by means of a spring-loaded valve plate. Increases in fuel system working pressures to 75 p.s.i. can be accommodated. In addition to meeting the requirements of Spec. AD103 $\frac{3}{4}$" B.S.P. to 2" B.S.P. are included in SDM. These valves have been subjected to vibration tests of ten million reversals.

Vickers Air Governor Valves

Used in pressure-cabin aircraft to control the pressure drop across the jets of various gyro instruments. These valves are fitted to the Gloster Meteor and de Havilland Vampire. Standard settings are as follows:

MARK	AIR CAPACITY CU.FT./MIN.	JET DROP INS.MERCURY
1	3.4 — 3.9	5.0 — 5.4
2	2.0 — 2.4	4.8 — 5.2
3	3.4 — 3.9	5.6 — 6.0
4	2.5 — 2.9	4.3 — 4.7

Other settings can be supplied as required.



A.T.76

Vickers-Armstrongs supply every kind of Valve and Fuel Cock . . .

for further details write to:

VICKERS-ARMSTRONGS LIMITED, WEYBRIDGE, SURREY

Pitman's Books

Aircraft Engines of the World 1949

By PAUL H. WILKINSON. A famous Annual, unequalled for accurate, up-to-date information on the world's aircraft engines. Profusely illustrated. 50/- net.
"Among the standard reference books."—*Journal of The Royal Aeronautical Society.*

Permanent Magnets

By F. G. SPREADBURY, A.M.Inst.B.E. A comprehensive work by an authority on this subject. Profusely illustrated. 35/- net.

Radio Frequency Heating Equipment

By L. L. LANGTON, A.M.I.E.E. Gives useful technical information with numerous circuit diagrams and other illustrations. 17/6 net.
"Rather more than the usual type of technical handbook."—*Timber and Plywood.*

Alloy Systems

By JAMES OSBORN FORD, Department of Metallurgy, Ohio State University. A new textbook of great value in the study of the processes and treatments comprising alloy technology. With numerous test questions, and 150 illustrations. 40/- net.

From all booksellers. Published by

PITMAN, *Parker St. Kingsway, London WC2*

James Booth

NON FERROUS METALS

THE quality and range of the non-ferrous metals produced by James Booth & Co. Ltd. are unequalled, even in Birmingham—the home of non-ferrous metals. Behind the Booth stamp on copper or brass, and behind the well-known trade-marks 'Duralumin', 'Aldural', 'Dural', 'Simgal', 'MG7', 'Elektron' etc. is the reputation of a firm world renowned for unvarying quality.

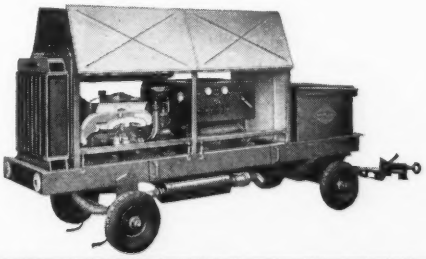
JAMES BOOTH & COMPANY LIMITED
ARGYLE STREET WORKS · BIRMINGHAM 7

BOOTH BIRMINGHAM

MUREX AIRCRAFT GROUND POWER UNIT

For Servicing and Starting all types of aircraft

The above illustration shows the new Murex aircraft ground power unit starting the engines of a Boeing Stratocruiser at London Airport. This unit is designed to supply the electrical current for servicing and starting all types of aircraft including piston engine, turbo-jet and turbo-prop types. The unit has an engine driven generator and eliminates the use of heavy service accumulators. The standard unit supplies a current of 600 amperes continuously at 28.5 volts for servicing and a peak current of approximately 1,200 amperes for engine starting periods. Other capacities are available.



MUREX AIRCRAFT GROUND POWER UNITS

MUREX WELDING PROCESSES LTD
WALTHAM CROSS - - HERT
GPU2 *Telephone : Waltham Cross 3636*

The first and only electrical Turn and Slip Indicator
approved for service with the ROYAL AIR FORCE
PULLIN
1000 HOURS NORMAL PERIOD
BETWEEN INSPECTIONS.
10 SLIP 10
TURN

Write direct for fully illustrated leaflet to the sole manufacturers—

R. B. PULLIN & CO. LTD., PHŒNIX WORKS, GREAT WEST ROAD, BRENTFORD, MIDDLESEX

Telephone EALing 0011/3 and 3661/3. Telegrams PULLINCO, Wesphone, London

16197

A NOTE ON REPEATED LOADING TESTS ON COMPONENTS AND COMPLETE STRUCTURES

by

H. L. COX, M.A. F.R.Ae.S., and E. P. COLEMAN

SUMMARY

The purpose of this paper is to describe a method for making repeated load tests and to illustrate several applications of the method.

The general characteristics of fatigue testing machines operating on the resonance principle are described, with particular reference to the mode of excitation. A method of excitation different from that in common use is described, and its advantages and disadvantages are explored. Four applications of the new method are instanced.

The new method proves particularly applicable to the repeated loading of complete structures and components, because it is readily adaptable to parts of awkward shapes loaded in special ways. Moreover, application of the method is not seriously restricted by large strains of the component under test, nor by moderately heavy absorption of energy by the component.

Several further applications of the method to the testing of complete structures are under consideration, and the development of types of fatigue testing machines based on the same method is being explored.

1. INTRODUCTION

The types of fatigue testing machine now most popular are the Wohler machine for alternating bending tests and, for direct stress tests, machines such as the Schenck or the Amsler Vibrophore, operating on the resonance principle. Other machines such as the N.P.L. combined stress machine and the Haigh machine for direct stress tests are also in general use, but for tests under direct stresses at least, and particularly for machines of large capacity, the resonance principle seems generally to be preferable.

The resonance principle itself is extremely simple (Fig. 1). The test-piece T, held fixed at one end E, has its other end attached through a fitting A to one end of the spring S; to the far end of the spring S is attached a mass B, which is movable along the common axis of the test-piece and spring S. By exciting resonant, or near resonant oscillations, of the mass B on the spring system comprising S, A and T, the test-piece T may be subjected to any desired range of load, while the exciter D, which maintains B in vibration, need itself apply only much smaller loads, the magnitude of which are determined mainly by the damping of the complete system.

The first published description of an application of this principle to a technical problem known to the writers is that by Aughtie[1], in 1931. Following this use of the principle its application to fatigue testing was explored further by Aughtie and Cox[2] in 1935. In this latter reference, the characteristics of the simple system illustrated in Fig. 1 were examined in some detail and the design of fatigue testing machines according to the resonant principle was thoroughly discussed; a preliminary test rig was constructed and operated successfully.

Since Ref. 2 was never published and is now not easily accessible, it appears desirable to restate some of the chief principles there established.

2. TECHNICAL DEVELOPMENT OF THE BASIC PRINCIPLE

The elementary system sketched in Fig. 1 is, in itself, a fatigue testing machine, but in order to turn the sketch into a practicable design, decisions have to be taken on the five points of detail now discussed separately.

Paper received November 1949.

Mr. Cox is a Senior Principal Scientific Officer at the National Physical Laboratory.

Mr. Coleman, late of the National Physical Laboratory, is now a Senior Experimental Officer at the National Institute of Agricultural Engineering.

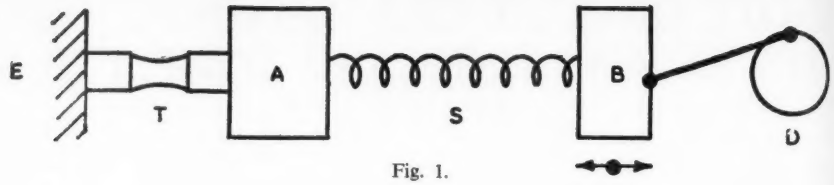


Fig. 1.

(*a*) The fixing *E* has to carry the full load range applied to the test-piece. This fixing can be provided either

(*i*) as a rigid framework securely anchored to the floor or wall of a building, or

(*ii*) as a heavy mass flexibly supported so as to permit small vibration of the whole mass relative to the ground, or

(*iii*) as a matched system exactly or effectively similar to the system *ASB* in Fig. 1.

For small load ranges (*i*) is appropriate, but for larger systems (*ii*) or (*iii*) is essential. The Schenck machine uses (*ii*) simply, the frame of the whole machine constituting the heavy mass. This has the advantage that static loading is facilitated, but the provision of a sufficiently heavy mass for some rigs may prove awkward. On the whole (*iii*) in conjunction with (*ii*) or (*i*) probably represents the best solution; the incidence of this consideration and its connection with the problem of static loading is discussed further in Section 4.

(*b*) As sketched in Fig. 1 the spring *S* has to carry both tensile and compressive loads. In the Schenck machine the springs are specially constructed for this purpose, but simple compression springs suffice for the arrangement sketched in Fig. 2.

Where only a unidirectional (pulsating) load system is required the arrangement sketched in Fig. 3, and illustrated in Fig. 7, is convenient and the spring *S′* applies the static loading required.

(*c*) Apart from the special case represented in Fig. 3, provision for applying static load must be made by fitting a separate spring *S′* between *A* and *E* in either Fig. 1 or Fig. 2 (*see* Fig. 4). This necessity occasions difficulty when method (*iii*) under (*a*) above is adopted and may render a compromise with (*a*) (*i*) or (*a*) (*ii*) unavoidable.

(*d*) Unless the stiffness of the test-piece *T* is very high in comparison with the stiffness of the spring *S*, the regulation of the machine will vary as the stiffness of the test-piece is varied. Regulation connotes the ratio of the range of load actually applied to that predetermined by the setting of the machine and maintained by the control system. The characteristic of the machine in respect of regulation depends on the principle of the control system, but it is not easy completely to avoid variation with stiffness of test-piece.

This problem is discussed fully in Ref. 2, but the principle may be illustrated by Fig. 4. If the mass *B* is vibrated through a fixed amplitude, the range of load developed in the spring *S* is reduced by the amplitude of vibration of *A* in phase with *B*. If the mass of *A* is adjusted so that it resonates at the frequency of operation on the springs *S* and *S′* in parallel, the range of load applied to *T* is merely proportional to the amplitude of vibration of *B*. Under these conditions regulation is perfect, but the control mechanism must maintain both the amplitude and frequency of vibration of the mass *B*. This condition can be achieved, but not with the methods of control at present in common use, because these methods operate by variation of frequency.

(*e*) No means have yet been indicated for excitation of the vibration of the mass *B* nor for the control of this vibration. In respect of these details two distinct schemes are available, and in the next

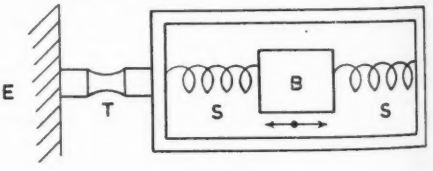


Fig. 2.

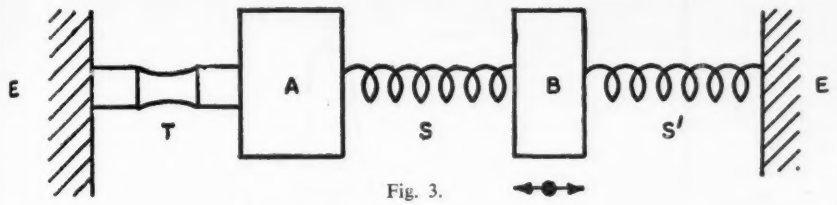


Fig. 3.

Section their relative advantages and disadvantages are reviewed in relation to requirements to which the exciter must be designed.

3. METHODS OF EXCITATION AND CONTROL

(a) *Fixed load excitation*

The basic principle on which any resonant machine operates is that at the operating speed the exciter need apply only a small part of the total range of load in the spring *S*. Yet provision must be made for starting up, so that a simple crank and connecting rod attached rigidly to *B* is useless, because the system cannot be started except by applying the full load range.

Electrical excitation by a magnetic drive of the loudspeaker type is ideal in that respect, because frequency can be preset. More generally, any exciter which is decoupled from the machine itself is satisfactory, but separate coupling must then be provided to afford means of control. In the Schenck machine excitation is provided by an out-of-balance mass on a rotating disc; since this mass is invariable and the speed range of the machine quite narrow, the excitation is in effect a fixed range of load. Back coupling is absent and control must be effected by other means.

If the machine (including the test-piece *T*) were run at resonance of the whole system, the range of load applied to the test-piece would be represented by the point *A* in Fig. 5; its magnitude would be determined entirely by the damping of the complete system, and variation of the damping would cause this range of load to vary in sympathy, for example, from *A* to *A′*. The capacity of the machine in relation to the size of the exciter is represented by the height of *A* in relation to the height of *C* and this ratio is to be made as large as practicable. As a result the height of *A* becomes very susceptible to variation of damping in the test-piece, so that regulation of the machine running at true resonance would be poor.

In order to improve regulation the machine is therefore run off resonance—usually below—at a point *B* and means of control are added to maintain the operating point *B* at the same height. In so far as the effective elastic stiffness and damping of the system may remain constant, the requirement for good regulation is merely to control the speed; yet, if the operating point *B* is to be satisfactorily high in relation to *C*, the tangent to the operating curve at *B* must be steep, and the standard of speed control required is stringent (say 1/10th of the standard of control of load range required: *e.g.* ± 0.1 per cent. for ± 1 per cent. control of load). Moreover, variation of damping either in the test-piece or elsewhere may vary the operating curve from *AB* to *A′B′*: speed control alone would cause the load range to fall from *B* to *B′*. Again, with a

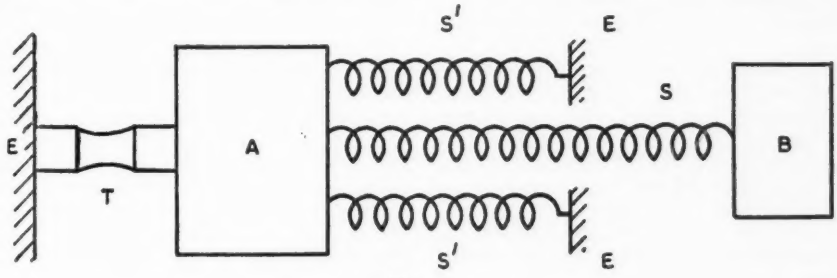


Fig. 4.

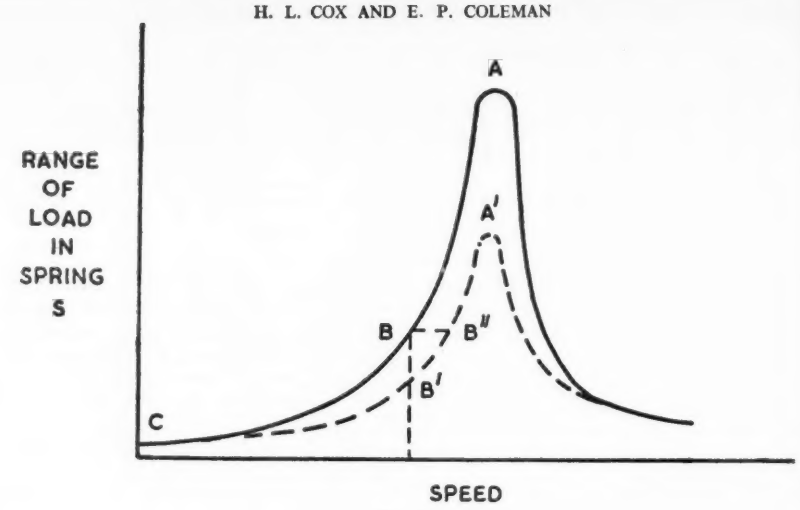


Fig. 5.

high ratio of B to C this fall represents poor regulation, so that means are provided to vary the speed and so to move from B to B''. As damping increases, the operating speed has to be increased, and *vice versa*. The effect of change of elastic stiffness is similar in that the operating curve AB is thereby shifted to right or left along the axis of frequency.

In the general case when the stiffness of the test-piece is not particularly high relative to the stiffness of the spring S, the choice of the element by which to effect control presents difficulty. The variation of operating frequency by which control is gained, itself precludes a simple system such as tuning of A on S and S' and control of amplitude of B, mentioned in Section 2(*d*). Control on the basis of the strain in a weighbar interposed between E and T or between T and A is always possible, but is seldom convenient. In the Schenck machine control is effected by maintenance of the amplitude of B relative to A, but no compensation for the movement of A itself is made.

This system is moderately good if the test-piece is very stiff, but it must be very imperfect if the test-piece is only ten or five times stiffer than the spring S. This imperfection concerns only variation of test-piece stiffness during test, because a separate weighbar in series with the test-piece is provided, by which reliance on previous calibration is obviated. The range of load applied can be set to the desired value by varying the speed until the weighbar reads the desired range and thereafter the control system will maintain this range so long as the characteristics of the test-piece remain unchanged.

The problems of control and regulation of a resonant machine excited by a "constant load" exciter become still greater when the energy absorbed by the test-piece is considerable, and particularly so when the energy absorption varies between wide limits. The operating point B must be chosen well down the operating curve and the exciter must be correspondingly large. At the moment when the out-of-balance mass on the exciter is moving parallel to the axis of the spring S, the mass B is being accelerated; this relative acceleration necessitates extra torque from the driving motor and this "power torque" appears as a "second harmonic" imposed on the steady torque required to overcome friction. Since the connection from the driving motor fixed to the frame of the machine to the out-of-balance exciter attached to the mass B is necessarily by a flexible shaft, transmission of the pulsating power torque may occasion difficulty. The system certainly works well for small power inputs, but the power input is limited by the size of the exciter, and increase of the exciter to provide more power would be likely to introduce parasitic troubles.

For the transmission of large powers an electrical exciter of the loud-speaker type would appear preferable, because it can

deliver efficiently the quadrature component of force required.

(*b*) *Fixed strain excitation*

In Section 2(*d*) it was remarked that perfect regulation could be achieved by running at constant frequency with a fixed amplitude of vibration of the mass *B*, but in (*a*) above it was noted that fixed amplitude of *B* could not be achieved by a simple crank and connecting rod, because starting would then require excessive load from the exciter. The latter difficulty may be readily surmounted by fitting a clutch between the drive and the mass *B*. On starting up the clutch slips until the driving motor speed approaches the resonant speed of the system, but so long as the friction at the clutch suffices to transmit the "power torque" (*see* (*a*) above) at mid stroke, at or near resonance, clutch slip ceases and the mass *B* is maintained in vibration at an amplitude determined by the throw of the driving crank.

Unless absolutely perfect regulation is essential, there is then no need even to control speed. In order to deliver power to the vibrating system the motor in the dead centre positions must tend to speed up; as the crank passes through these positions it starts to push or pull on the connecting rod and the motor tends to slow up as a result. Should the slowing up be too pronounced, in the next half cycle less power is delivered to the vibrating system and this process continues until the motor stalls. Should the motor speed be too little reduced, the force in the connecting rod in the next half cycle is increased, and this process continues until the clutch slips, when the vibrating system falls out of resonance and the motor races away to a speed well above resonance. In between these two extremes there is a range of frequencies over which the mutual interaction of motor and vibrating system is sufficiently well balanced for clutch slip not to occur, and the system may be operated anywhere within this range.

The width of the permissible frequency range increases as the clutch friction is increased, but it is finally limited by the capacity of the driving motor. The power component needed to overcome damping in the vibrating system is delivered at mid stroke, and large powers up to the capacity of the motor may readily be delivered. On the other hand, to force vibration at a frequency other than the resonant frequency, necessitates an "in phase" component of load, that is load in the connecting rod at the dead centre positions. This condition is hard on the motor bearings and crankpin, so that for this reason it is preferable to run very close to the true resonant speed. In practice it proves desirable to run slightly above resonance, in order to provide a margin of reserve power to meet increased power loss in the test-piece or elsewhere.

A piston driven through a connecting rod by a simple crank or eccentric rotating at uniform speed does not afford a perfect sinusoidal motion. The harmonic content of the wave form, however, may be reduced by using a long connecting rod and no more elaborate means to "match" motor and vibrating system is needed. It is preferable to take up backlash in the crank and connecting rod system by subjecting it to a spring load, although this refinement is not essential.

Since nothing more need be said about either control or the essential function of the exciter, the remaining points of practical value may best be explained by reference to the four applications to which the general method has been put.

4. PRACTICAL APPLICATIONS

Apart from the early experiments described in References 1 and 2, the slipping clutch method, so far, has been applied at the National Physical Laboratory to four structures of widely different natures. This variety has afforded opportunity to explore the merits of the method fairly thoroughly, and the practical experience gained is being applied to the design of new rigs and actual fatigue testing machines.

The four structures tested comprise:—

(*i*) Two small aircraft wing segments, each 64 inches span, 36 inches root chord and 6 inches maximum root thickness; tested as cantilevers in flexural oscillation with and without static load.

(*ii*) A helicopter blade about 13 ft. long constructed of an aluminium alloy tapered tube with a trailing edge of magnesium alloy sheet structure and a root fixing permitting rotation of the whole blade about its axis; tested as a cantilever in flexural oscillation with static load.

(*iii*) An elevator hinge bracket of welded construction in magnesium alloy, about

9 inches long and 4 inches deep at root; tested as a cantilever under pulsating load.

(*iv*) A rubber-bushed steel flexible coupling about 12 inches in diameter with four one-inch driving pins in pairs at opposite ends of two diameters at right angles on a $7\frac{3}{8}$ inch pitch circle; tested in torsional oscillation about the axis of rotation of the coupling.

In case (*i*) the wing was supported in a horizontal position from a root fixing attached to a vertical wall. The slipping clutch drive (shown in Fig. 6) was attached to the face of the tip section at about mid-chord and was driven through a connecting rod about 36 inches long by a crank on a motor mounted on the floor below the wing. In the absence of means to bolt the motor to the floor, the motor was held in position by four 100 lb. weights standing on bed-rails to which the motor frame was bolted. After preliminary tests with a tip amplitude of $\pm\frac{1}{8}$ inch, tests to destruction were run with tip amplitudes of $0-\frac{3}{4}$ inch, the static loading being provided by two tension springs attached to straps passing round the complete wing section at intermediate positions along the span.

In these tests the crank-pin was of mild steel 5/16 inch in diameter, running in a copper bush. Lubrication (by drip feed) was very imperfect and considerable wear of both pin and bush occurred. The back-lash in the drive was taken up by a spring load and the performance of the rig was not seriously affected by this wear.

These tests demonstrated that the method of drive was quite feasible, that self-regulation of motor speeds was satisfactory, but the detail of the drive needed to be improved. The rig was left running unattended and failure of the second wing occurred during the night. This failure occurred by complete fracture across the tension side of the wing at the attachment to the root fixing. No provision had been made for cutting out the motor, which merely stalled. It is a principal merit of this type of drive that there is no possibility of the range of load having been increased beyond that imposed by the crank throw.

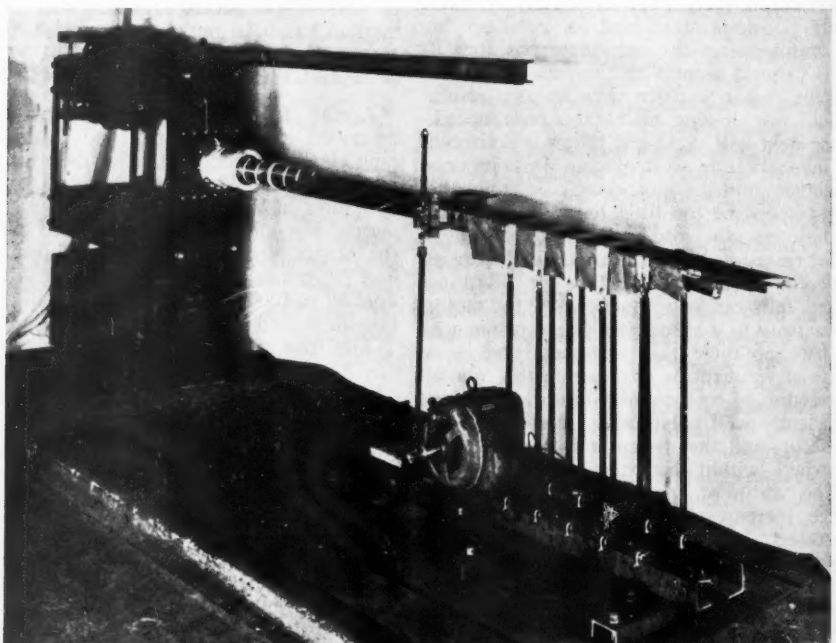


Fig. 6.

Had the clutch been adjusted more loosely the extra damping and/or the change of resonant frequency consequent upon the initial crack would have led to slip at the clutch and the motor would have "shed its load"; but with the clutch set tightly the force transmitted could increase sufficiently to break the wing completely and eventually to stall the driving motor, yet the amplitude of steady vibration could not possibly increase beyond that preset by the crank throw.

The first test on case (*ii*) was also run with the blade supported on a vertical wall, but the vibration transmitted to the building evoked strong complaints, and cracks appeared in the wall. The method Section 2(*a*)(*i*) had therefore to be abandoned in favour of the method Section 2(*a*)(*ii*). The requisite heavy mass was constructed of two ton masses attached one above the other by four corner posts (*see* Fig. 6). With this composite mass mounted on rubber blocks (borrowed from a Schenck machine) and with the blade attached as shown in Fig. 6, but without the overhanging beam shown in that photograph, the movement of the mass on the rubber blocks was so great that the energy loss in the rubber proved excessive. This energy had to be supplied from the driving motor through the clutch and blade. Accordingly the rubber blocks were replaced by coiled steel springs. By this change the energy dissipation was eliminated, but the whole rig became inconveniently flexible, so that it proved extremely awkward to impose the static load required. Finally, therefore, the "tuner," composed of two $3 \times 1\frac{1}{2}$ channel sections was fitted above the blade, and the movement of the anchor mass was thereby so much reduced that the rubber blocks could be replaced without causing too large a dissipation of energy.

Both the static load and the dynamic drive were imposed relative to the floor, as shown in Fig. 6. It would probably have been preferable to fix both the motor and the ends of the static load springs to the tuner above the wing, but for the static load this could have been affected only by increasing both the length and section of the tuning member and for the dynamic drive, by almost doubling the throw of the crank.

After trials of several other systems it was found best to apply the static load by means of a large number of small tension springs. The amplitude of vibration at the blade tip was about 8 inches, so that the outermost static springs needed to have at least 4 inches and preferably 6-8 inches extension. For this reason they had to be rather long, and that again provided a reason for attachment to the floor rather than to the tuner. A certain amount of trouble was experienced (and is still being experienced) with the static springs, and some care had to be exercised to avoid appreciable dissipation of energy in these springs and their attachments. A moderately satisfactory arrangement was finally achieved, but still the blade runs much better without the static load. It is probable that the effect of the static load in varying the ranges of load imposed on the rubber blocks supporting the anchor mass contributes to this effect.

In the preliminary stages several modes of dynamic drive in several positions along the span of the blade were tried. An attachment near the root, just inboard of the end of the trailing edge, was preferred, both because a rigid fixing could be provided more easily there than elsewhere, and because the amplitude of movement required there was only about $\frac{1}{4}$ inch. It proved impossible, however, with the light connecting rod and crank to develop sufficient force, and increase in size of these parts would probably have merely transferred the trouble to the motor bearings, or to its holding down bolts. The next 30 inches outboard being virtually inaccessible owing to the large width of the trailing edge, the drive had to be attached at the inboard end of the aileron gap at a point where the amplitude of vibration required was about $2\frac{1}{2}$ inches. With so large a throw, the connecting rod 26 inches long was still rather too short, and both obliquity of the connecting rod and lack of lateral balance prevented really sweet running, while lubrication of the crank pin was rendered very difficult. However, even with a steel crank pin $\frac{3}{8}$ inch in diameter running in a phosphor bronze bush, the performance was reasonably good and improvement was later effected by replacing the plain bearing by a small ball bearing.

The friction clutch used in these tests was that previously used in case (*i*). It proved adequate, but the heavier loads were really beyond its capacity and eventually it was replaced by a larger unit.

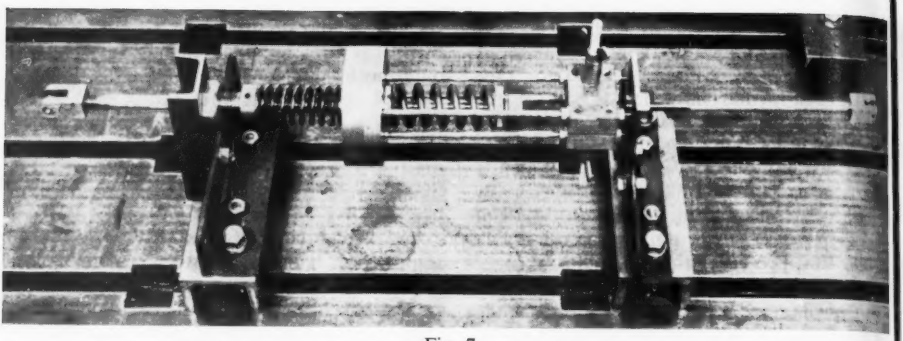


Fig. 7.

Although the slipping clutch method of drive cannot overload the system as a whole, when the clutch slips it is possible to set up rather heavy local loads. This danger was severe in the present case, because the structure to which the drive had to be attached was rather light. After serious local damage had been caused in one trial, the method of attachment was modified to reduce this danger. At the same time the spring, which had previously been used on the end of the driving piston to take up back-lash in the drive, was discarded, because through this spring, when compressed solid, heavy load could be imposed; this condition could occur when, in the course of the blade falling out of resonance, momentarily the vibration of blade and drive could be in antiphase.

In general these tests on the helicopter blade have shown the need for considerable care in design of the mass-balance system (that is the anchor-mass, tuner and the support of the anchor-mass), of the static loading arrangement and its attachment and of the attachment of the slipping clutch drive. With regard to the last item, it might well be preferable to drive the tuner rather than the test-piece itself. This would have been tried on the present rig had the general arrangement been such that the trial could be made easily, but it will be seen from Fig. 6 that direct access to the tuner was prevented by the blade itself. If the tuner were driven, the amplitude of oscillation of the blade would be determined only indirectly, yet by observation of the tuner when the blade was driven it appeared that the amplitude of oscillation of the balancing element may be controllable within quite close limits.

In both cases (*i*) and (*ii*) the mass *B* and the spring *S* of Fig. 1 had become in effect absorbed in the test-piece itself; if the test portion be regarded as the root fixing*, the outer portion of the wing or blade represents by its stiffness the spring *S* and by its mass the mass *B*. The heavily tapered helicopter blade represents in this aspect the worst possible type of system to excite. Its bad quality in this respect is evidence of the goodness of its design for its proper function.

In case (*iii*) an almost complete return was made to the basic example Fig. 1. In fact the only change from Fig. 3 was that the mass *A* took the form of a long rod returning through the springs *S* and *S'* and the mass *B* to the test-piece, which was fixed to the base plate beyond the clamp at the end of the spring *S'* (*see* Fig. 7). This arrangement was adopted to leave a clear run for the connection of the slipping clutch to the mass *B* and for the drive beyond. The load range required was only of the order 200 ± 150 lb., and the rig ran excellently well. The only points of interest in relation to general principles were occasioned by minor faults in the detail design. At one time, owing to excessive clearance and bad lubrication, heavy

* As a matter of general interest it may be remarked that the failures to date experienced on the helicopter blade—under an overload condition—have been two root sleeve attachments, the tip broken completely off, and cracks in both upper and lower surfaces in the root portion of the magnesium alloy trailing edge structure. The tip and trailing edge fractures were of considerable interest in relation to diffusion problems in general; the fractures of the root sleeves, about 7 in. diameter and $\frac{3}{8}$ in. wall thickness, occurred in the fillet radius, and a third sleeve having this radius very much increased has now withstood about $1\frac{1}{2}$ million cycles of a still greater range of load without any sign of failure.

friction developed and certain of the moving parts were seriously abraded; yet this had scarcely any effect on the operation of the rig. Since the drag developed in the middle of the stroke the motor was well able to supply the required power even to the extent of acting as a quite passable filing machine. On the other hand, when at another time a poor quality spring was used, which set and eventually fractured, the demand this made for power input at the dead centre positions rendered the rig almost impossible to operate. These observations point the main merit of the direct drive, that it can supply any amount of power, and also the main defect of the method, that the energy absorbed at the extremes of the stroke must be supplied by the inertia and subsequently made up by the drive. It is in this respect that the helicopter blade proved so awkward to excite; the inertia of the blade is so small that the kinetic energy stored in the blade at mid stroke is seriously reduced by energy loss due to cracking or to permanent set at the ends of the stroke.

In the fourth case, the main object of the tests was to determine the energy absorption† of a "Layrub" coupling. The test rig is shown in Fig. 8. The slipping clutch was attached to the underside of the plate shown in this photograph at one side of the steel channel, which formed the oscillating mass equivalent to *B* in Fig. 1. No particular care was taken to balance the arrangement nor to arrange the drive at the plane of symmetry. The resonant frequency of the oscillating beam in pitch was very low and this motion could readily be excited by running at the correct low speed. Yet at the higher speed for resonant torsional oscillations no trace of pitching could be detected, this motion at the higher speed being most effectively prevented by the inertia of the oscillating beam.

Because of the heavy damping in the rubber bushes, the resonant frequency was not well marked and the rig ran almost equally well over a fairly wide speed range. When running close to resonance without spring load to take up backlash, the best speed could be judged by noticing a slight clatter from the connecting rod, which occurred when it became slack at the dead centres. In the present case the whole rig was too noisy for this test to be applied, and reliance had to be placed on the second check that at resonance the crank-pin and bearing keep reasonably cool, while above or below resonance they heat up much more.

With this rig it proved possible to transmit 300 watts from a ½ h.p. motor at a speed of about 800 r.p.m. Apart from heating at the crank-pin no trouble was experienced and as the tests were run only for an hour or so, wear at the crank-pin bearing was unimportant.

5. FURTHER DEVELOPMENTS

When it is required to transmit considerable energy the clutch setting must be reasonably tight, and with a small exciting motor* it may prove impossible to start with the clutch preset in the running condition. The technique adopted in cases (*ii*) and (*iv*) of Section 4 has been to slacken the clutch, start the motor and run well above the resonant speed, then tighten the clutch before reducing speed to resonance. In case (*iv*) this technique worked very satisfactorily, but in case (*ii*) it was more spectacular than impressive, because at the clutch setting needed for satisfactory running the heat developed by friction during the short period while the clutch slipped under load was sufficient to char the clutch lining. Moreover, as the clutch is tightened, the blade starts to be dragged by the drive, so that the clutch tends to be jerked out of the fingers of the operator tightening it.

An attempt has been made to interpose a linkwork so as to bring the clutch to a stationary position. A first trial of a similar arrangement in case (*ii*) was quite unsatisfactory and a second trial in case (*iv*) was only moderately promising. If the clutch-tightening technique were adopted for a large rig or full testing machine, the clamping device would be operated by hydraulic pressure or similar means, but even so, such a unit would be easier to design if it were stationary rather than if it were required to vibrate with the oscillating mass.

† All four tests were made for private firms and the observations made in this report were all incidental to the main purposes of the tests.

* All the present tests have been run with a ½ h.p. motor; for the helicopter blade, however, a 2 h.p. motor was later substituted. This is rather unnecessarily large and a 1 h.p. motor would have been preferred, had a suitable machine been available.

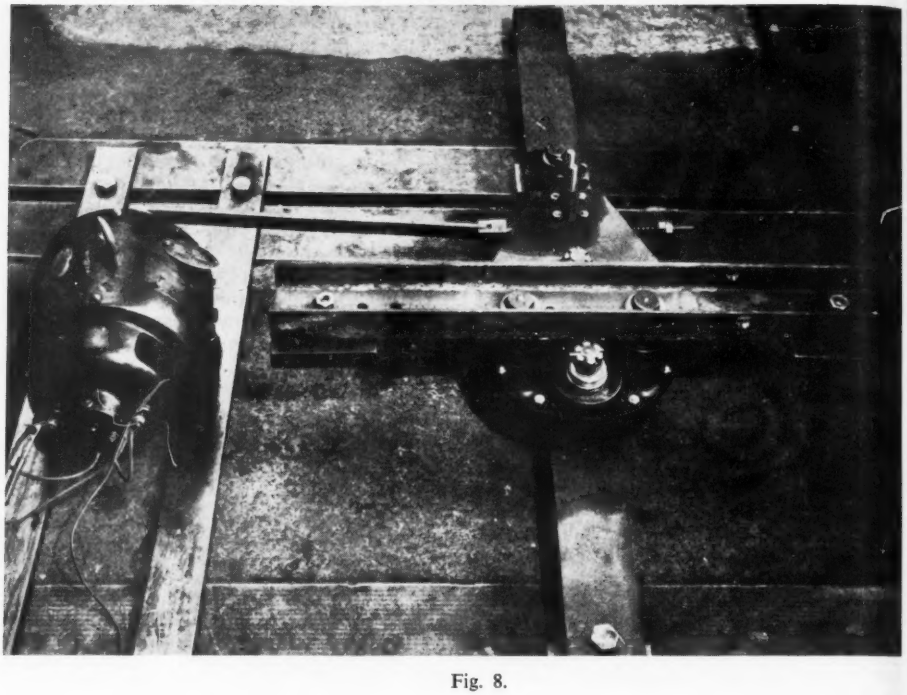


Fig. 8.

At present an alternative scheme is being developed by which the drive may be brought to the resonant speed before the crank throw is set. If this mechanism should prove successful it would at once eliminate the need for a slipping clutch and would also provide means for continuous variation of the load range imposed. The doubtful feature of this mechanism is that it involves a certain number of intermediate links, and it is at present uncertain whether the interposition of this linkwork may not dangerously reduce the tightness of coupling between motor and oscillating system. If this coupling is insufficiently tight the necessary interaction between the two units described in Section 3(*b*) is precluded and the system will not operate. This necessity was well demonstrated when case (*ii*) was first set up; in order to insulate the motor bearings from the loads reacting from the blade a separate unit was provided, driven through a flexible coupling. The torsional stiffness of this coupling proved insufficient and satisfactory running was never achieved.

In the expectation that a satisfactory design of variable throw drive should eventually be developed, consideration is being given to the design of fatigue testing machines driven in this way. It is considered that such machines should prove particularly useful for tests on joints and jointed components, because considerations of energy absorption should occasion much less trouble than in other machines driven by " fixed load " exciters.

Meanwhile further tests on structural components by means of *ad hoc* rigs are also under consideration.

ACKNOWLEDGMENT

The work described was done in the Engineering Division of the National Physical Laboratory, and this paper is published on the recommendation of the Aeronautical Research Council and by permission of the Director of the Laboratory.

REFERENCES

1. AUGHTIE, F. A Source of Mechanical Vibration for Experimental Purposes. *Phil. Mag.*, Vol. XI, supplement p. 517, 1931.
2. AUGHTIE, F., and COX, H. L. A New Type of Fatigue Testing Machine. A.R.C. Rep. No. 1880, 1935.

DIRECTIONALITY OF WROUGHT LIGHT ALLOY MATERIALS

by

I. L. G. BAILLIE, B.Sc., G.I.Mech.E.

INTRODUCTION

The principal materials employed in modern aircraft structures are aluminium-rich alloys which the aircraft manufacturer will normally buy in the semi-finished (cast or wrought) state. Wrought materials fall into the four main classes of tubes, sheets, extrusions, and forgings; each of these forms inherently exhibits distinctive mechanical strength characteristics. In this paper the relation of the mechanical properties of medium and high strength wrought light alloy materials to the grain direction, and the implications of this relation in aircraft design, will be discussed.

DIRECTIONALITY IN TUBES

Light alloy tubes are extruded and often subsequently drawn through dies. Crystal grains, together with any impurities or discontinuities in the material, must therefore be elongated in the direction of the longitudinal axis of the tubes. Because of this directionality it would be undesirable to apply loads tending to separate the longitudinal fibres of the material. Fortunately, tubes are mainly employed in direct tension, compression, or torsion, superimposed upon any of which may be bending, and none of these results in primary transverse tension. Furthermore, conventional stressing methods are combined with design stresses based upon tensile, compressive, torsional, and bearing tests which, by the nature of the form of tube material, automatically include the effects of directionality.

DIRECTIONALITY IN SHEETS

Coiled sheets, trimmed strip, and rolled sheets will be treated together under this heading. Comparison of tensile and compressive test results, for specimens extracted longitudinally or transversely in relation to the principal axis of rolling of the sheet, indicates no serious directionality effect. DTD.546 is the specification for one of the most frequently employed aluminium clad high strength light alloy sheet materials; in Fig. 1 are quoted test results which indicate that, for this material, the ratio of transverse to longitudinal properties is 0.96 for proof stress and 0.99 for ultimate. No significant difference was noted in elongation values in the two directions. 270 longitudinal and 54 transverse specimens are represented in this analysis.

Except for coils and trimmed strip less than 12 in. wide, light alloy sheet materials are accepted, by Inspection, as conforming to specification upon the basis of results of tests upon specimens extracted transversely with respect to the direction of final rolling. Design stresses are closely related to minimum specified tensile properties, and designers are thereby automatically insured against directionality troubles.*

Prize-winning paper submitted for the Bristol Branch Junior Members' Papers Competition, 1949.

Mr. Baillie is Materials Engineer, Engineering Development Laboratory, Bristol Aeroplane Co. Ltd., Aircraft Division.

* Tests on rolled plates (about 1¼ in. thick) have demonstrated that the relationship between longitudinal and transverse properties is similar to that in the sheets; in the vertical direction (*i.e. through* the plates) stresses appeared to be almost as high as in the other directions, but ultimate elongations down to 1½% have been recorded.

DIRECTIONALITY IN DTD. 546 SHEET

Sheet Thickness in.	0.1% *Proof Tensile Stress*			*Ultimate Tensile Stress*		
	Long Tons/in²	*Trans Tons/in²*	*Ratio Trans/ Long*	*Long Tons/in²*	*Trans Tons/in²*	*Ratio Trans/ Long*
0.022	25.9	24.2	0.93	29.8	28.9	0.97
0.028	25.4	24.4	0.96	29.0	28.7	0.99
0.036	26.5	25.2	0.95	29.9	29.8	0.99
0.048	26.4	25.2	0.96	29.7	29.1	0.98
0.064	25.2	24.1	0.96	28.6	27.9	0.98
0.080	23.3	23.8	1.02	27.2	28.2	1.04
All	25.4	24.4	0.96	28.8	28.6	0.99

Fig. 1.

BARS, EXTRUSIONS AND FORGINGS

All light alloy components not manufactured from castings, tubes, or sheets, will be manufactured from wrought material under this heading. The remainder of the paper, therefore, must be considered as applicable to all such components.

To simplify description of the various forms of material, the following groups will be used:—

1. Extrusions—this group includes extruded sections and extruded bars; the latter form the majority of bars for machining.
2. Die forgings—this group includes pressings, stampings, die forgings and drop forgings.
3. Forged stock—this group includes forged billets, hammered bars, and hand forgings.

The form of directionality which occurs in material in each of these groups will now be examined separately.

Directionality in extrusions

BSS.L.1 is a specification which, besides forgings, covers bars and extrusions, the minor sectional dimension of which is not greater than 3 in.; BSS.L.39 is a similar specification for the same "duralumin" alloy when the minor sectional dimension is greater than 3 in. In Fig. 2 are quoted the mean results of tests on six longitudinal and six transverse tensile specimens from a bar to each specification from five manufacturers, *i.e.* a total of 120 specimens. The mean ratio of transverse to longitudinal properties is 0.75 for both proof and ultimate tensile stresses, ranging from 0.83 to 0.70 for different manufacturers; on individual associated tensile specimens the ratio ranged from 0.86 to 0.64. The mean ratio of transverse to longitudinal ultimate elongation values is some 0.40, ranging from 0.70 to 0.23; on individual associated tensile specimens the ratio ranged from 0.92 to 0.01.

DTD.364 is a specification widely used in aircraft; it is similar to L.1 and L.39, but the alloy is somewhat different—the core of DTD.546 sheets already mentioned is to the same composition as DTD.364. Comprehensive tests to determine directionality effects in DTD.364 extrusions have not yet been made, but a summary of available results is given in Fig. 3. The scatter in these results is considerable, but it is to be noted that the ratio of transverse to longitudinal ultimate tensile stress values falls to 0.77; the value of this ratio for ultimate elongation values falls to 0.11 for specimens from the 8 in. diameter bar and, on individual associated tensile specimens from the 3 in. diameter bar, it falls to 0.22.

Specifications for these and similar extruded materials require that a longitudinal specimen shall give proof and

DIRECTIONALITY IN L.1 AND L.39 EXTRUDED BAR

Manufacturer (Shown by Code J-N)	0.1% *Proof Tensile Stress*			*Ultimate Tensile Stress*			*Ultimate Elongation*		
	Long Tons/ in²	*Tons/ in²*	*Ratio Trans/ Long*	*Long Tons/ in²*	*Trans Tons/ in²*	*Ratio Trans/ Long*	*Long %*	*Trans %*	*Ratio Trans/ Long*
3″ dia. L.1 bar									
J	21.6	16.0	0.74	33.6	27.7	0.83	16½	11½	0.70
K	21.3	15.9	0.75	32.6	23.2	0.71	17	6	0.35
L	23.0	16.9	0.73	34.3	25.0	0.73	15	3½	0.23
M	22.1	16.5	0.75	32.4	24.0	0.74	16	6	0.37
N	22.8	15.9	0.70	31.6	23.6	0.75	14	6	0.43
All	22.2	16.3	0.73	32.9	24.8	0.75	15½	6½	0.42
6″ dia. L.39 bar									
J	19.5	14.7	0.75	30.7	21.9	0.71	11½	4	0.35
K	20.7	15.7	0.76	32.5	24.5	0.75	17½	6½	0.37
L	19.4	15.4	0.79	30.6	23.3	0.76	15	5½	0.37
M	20.9	16.2	0.77	30.9	22.6	0.73	13½	5	0.37
N	20.8	16.3	0.78	31.6	24.4	0.77	14	5½	0.39
All	20.3	15.7	0.77	31.3	23.3	0.75	14½	5½	0.37

Fig. 2.

DIRECTIONALITY IN DTD.364 EXTRUDED BAR

Bar Size	0.1% *Proof Tensile Stress*			*Ultimate Tensile Stress*			*Ultimate Elongation*		
	Long Tons/ in²	*Trans Tons/ in²*	*Ratio Trans/ Long*	*Long Tons/ in²*	*Trans Tons/ in²*	*Ratio Trans/ Long*	*Long %*	*Trans %*	*Ratio Trans/ Long*
3″ dia. 6 long. and 9 trans. results	29.1	25.2	0.87	33.4	29.0	0.87	11	7	0.64
8″ dia. 1 long. and 2 trans. results	21.8	19.3	0.93	28.9	22.3	0.77	11½	1¼	0.11
3″ x 2¼″ 4 long. and 2 trans. results	28.8	—	—	31.8	28.6	0.90	11	3½	0.32

Fig. 3.

ultimate tensile stresses, and ultimate elongation, not less than specified values. Except when the minor sectional dimension is less than one inch (when the test specimen shall be extracted from the centre of the cross-section), the axis of the specimen need be only 9/16 in. from the surface. The strength of large extrusions falls considerably towards the centre of the bar because of the mass-effect during quenching in the heat-treatment and it is suggested, although direct evidence is not yet available, that the ratio of transverse to longitudinal properties is approximately constant throughout the cross-section.*

In conventional aircraft design the appropriate minimum value quoted in the relevant material specification is employed, but this is unlikely to be satisfactory when the loading is transverse, or when the material concerned originates from the central region of a large extrusion.

* Direct evidence since this paper was first written has shown this suggestion to be reasonably correct for stresses. From the outside to the centre of a large bar, however, the ratio of transverse to longitudinal ultimate elongation values decreased markedly; also, circumferentially transverse properties were more satisfactory than radially tranverse properties, near the bar surface (which suggests a reason for the good service record of pressure-resistant components extracted near the bar surface).

Directionality in die forgings

The mean results of tests on a total of 238 specimens extracted in various directions with respect to the primary grain direction, from a number of die forgings in various materials, are quoted at the top of Fig. 4. Except for DTD.410 results, the ratios of transverse, or vertical, to longitudinal properties are always greater than 0.9 for proof and ultimate tensile stresses; the slightly lower value of 0.88 for DTD.410 reflects a forging of exceptional size and manufacturing difficulty. Wide scatter is associated with the ratios of transverse, or vertical, to longitudinal ultimate elongation values, which range from 0.92 to 0.07. Although the test results have been omitted for brevity, specimens extracted at 45° to two planes give properties approximately midway between the properties in the two planes.

Specifications for forging material quote strength requirements for a tensile specimen which is employed as a control upon heat-treatment. No direct strength requirements are laid down for the forgings themselves other than the requirement that the materials used shall, before forging, meet certain strength requirements. Although easy to operate in practice, this procedure can mislead designers since the forging operations result in a loss of strength and, furthermore, the

DIRECTIONALITY IN FORGED LIGHT ALLOY

Material Specification	0.1% *Proof Tensile Stress*			*Ultimate Tensile Stress*			*Ultimate Elongation*		
	Long Tons/ in²	*Ratio Trans/ Long*	*Ratio Vert/ Long*	*Long Tons/ in²*	*Ratio Trans/ Long*	*Ratio Vert/ Long*	*Long %*	*Ratio Trans/ Long*	*Ratio Vert/ Long*
Die Forgings									
L.39	15.1	0.91	—	27.0	0.91	—	23½	0.85	—
L.40	21.4	0.94	0.99	27.4	0.98	0.96	12	0.92	0.42
L.45	21.2	0.99	1.01	26.6	0.96	0.97	7½	0.60	0.53
DTD.364	25.0	0.99	0.99	30.2	1.01	0.99	13½	0.81	0.67
DTD.410	20.0	0.96	0.92	26.4	0.92	0.88	8	0.44	0.25
DTD.423	18.3	—	0.97	21.4	—	0.99	16	—	0.69
DTD.683	29.5	0.99	1.00	33.4	0.98	0.93	15	0.33	0.07
Forged Stock									
DTD.364	27.4	0.93	0.84	30.9	1.00	0.92	11	0.65	0.47

Fig. 4.

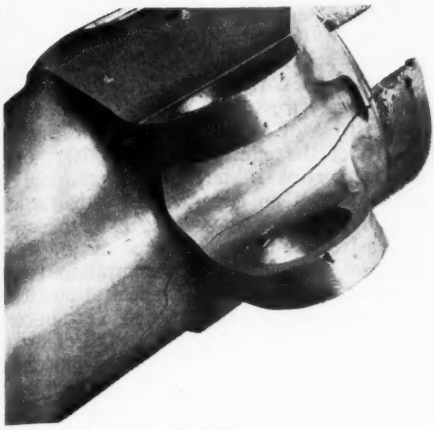


Fig. 5.
Large DTD.410 forged cylinder: failed at 60% design load.

heat treatment control specimen may be manufactured from extruded bar and then possess higher strength values than it would had it been forged. It has been suggested that this drop is 10 per cent. for tensile stresses, and 60 per cent. for elongation, longitudinally.

The aircraft designer thus has to consider first the drop in strength properties in a forging, as compared to the specification requirements for the heat-treatment control test piece, and secondly, the further drop in transverse properties compared to longitudinal.

Directionality in forged stock

The mean results of a total of 58 tensile tests on specimens extracted from four hand forgings in DTD.364 are quoted at the base of Fig. 4. The ratios to the longitudinal properties of transverse and vertical tensile stresses tend to be somewhat lower than for die forgings, but the ratio for ultimate elongation is no worse. It is thought that a thorough three-dimensional forging operation will reduce directionality effects and therefore tend to increase this ratio in forged stock.

Drops in forged stock properties due to directionality and to inspectional procedure, as compared to specification requirements, are as for die forgings.

DIRECTIONALITY RESULTING IN UNPREDICTED FAILURES OF AIRCRAFT COMPONENTS

The summarised test data already presented indicate the form of directional variation in wrought light alloys. The inadequacy of conventional stressing methods, directional variation, and the non-applicability of specification strength requirements to design for certain forms of material, may singly, or together, be greater than the reserve in strength represented by the ratio of permissible strength for the material to the maximum applied stress and/or the reserve in strength of material employed, since material is normally stronger than the appropriate minimum specified value would suggest.

When the adverse effects are greater than strength reserves, unpredicted failure will occur below the maximum design load. A number of such apparently premature failures has occurred in recent months; they included:—

(*a*) A very large DTD.410 forged cylinder, the failed end of which is shown in Fig. 5; this part failed at 60 per cent. of design load; principal loads were transverse upon the material at the region of initiation of the crack, and failure may have been precipitated by the proximity of a hole to a free edge.

(*b*) A long cylindrical part, manufactured from DTD.683 extruded bar, which failed at 37 per cent. of design load; principal loads were again transverse, and there was a hole near a sharp change of section.

(*c*) A pressure-resisting cylindrical part with thin walls and a central boss, manufactured from DTD.364 rectangular forged slab, which failed, at a circumferential hoop stress of 13.4 tons/sq. in., with a longitudinal crack of typical short appearance.

(*d*) A T-section machined from DTD.364 extruded bar, which failed through a line of rivet holes at a mean stress of about 11 tons/sq. in., the loading being transverse with respect to material grain.

Other failures included a large T-shaped fitting which failed during assembly, a flanged semi-circular ring which failed, under test, almost immediately due to

fatigue loading, and joggles in Z-section stringers. These parts were all manufactured from DTD.364 material. It is understood that at least three aircraft constructors have recently been experiencing unpredicted failures of these types.

INFLUENCE OF STRESS-RAISERS

Except perhaps for the pressure-resisting cylinder, in which failure may have been precipitated by the presence of a "plane of low cohesion," fortunately a rare occurrence, all the main unpredicted failures have been associated with either holes or with sharp changes of section, both of which act as stress-raisers. That is, local stress in the immediate vicinity of the stress-raiser is higher than conventional stressing methods would indicate.

With a perfectly elastic material, it may be shown theoretically that a hole in an infinitely wide plate loaded in tension constitutes a stress-raiser of 3 (*i.e.* there would be a local stress of 12 tons/sq. in. for a mean stress of 4 tons/sq. in.). Little is yet known of the effects of stress-raisers once the proportional limit of the material is exceeded, but an American investigator has demonstrated, as shown in Fig. 6, that with a plastic material, as the mean stress increases so the stress-concentration factor decreases and the strain-concentration factor increases, and he has recorded a strain-concentration factor of 7.10 with a fall of stress-concentration from 2.57 to 1.21. This form of variation is understandable, since plastic strain will occur in such a manner as to attempt to equalise the unequal stresses.

For design purposes the effects of both

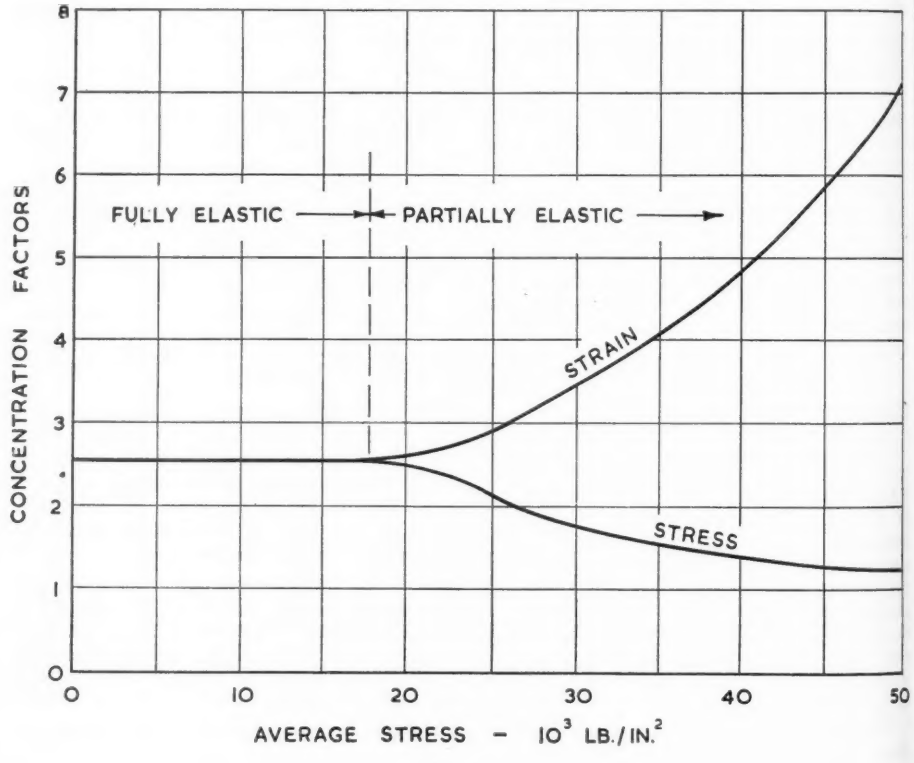


Fig. 6.
Stress concentration factor in a plastic material.

MINIMUM RECORDED ULTIMATE ELONGATION VALUES FOR LIGHT ALLOY EXTRUSIONS AND FORGINGS

Material Specification	*Minimum Recorded Ultimate Elongation on* $4\sqrt{A}$ %							
	Extrusions		*Die Forgings*			*Forged Stock*		
	Long.	*Trans.*	*Long.*	*Trans.*	*Vert.*	*Long.*	*Trans.*	*Vert.*
L.1	12½	0.2*	—	—	—	—	—	—
L.39	10	3	23½	9	—	—	—	—
L.40	—	—	2½†	3	1	—	—	—
L.45	—	—	4½	2½	3½	—	—	—
DTD.364	8½	1½	8	6	2½	10	4	1½
DTD.410	—	—	5½	2½	2	—	—	—
DTD.423	—	—	13½	—	11	—	—	—
DTD.683	—	—	11	1½	1	—	—	—

* Below 0.2% proof stress: Next lowest value 1½%
† Suspect value: Next lowest value 5%

Fig. 7.

stress- and strain-concentration factors must be considered. For longitudinal loadings it is expected that elongations will be sufficient to accommodate strain-concentration factors of the order of 7, and stress-concentrations will give design criteria. For transverse loadings, the very low elongation values which can occur may give a lower design stress from strain-concentration than from stress-concentration factors, and strain-concentration factors, therefore, might give the design criteria.

Consequently it is important for adequate information to be available about the minimum elongation values likely to be encountered in the transverse and vertical directions. The minimum recorded values are quoted in Fig. 7. Although these values are the low ends of histograms, some of which were small, they indicate the order of these minimum elongations which need to be considered in design where there are stress-raisers which can result in high strain-concentrations. Elongation values less than two or three per cent. may be sufficiently low to result in apparently premature failures.

DESIGN IMPLICATIONS OF DIRECTIONALITY

In this brief discussion some major features of directionality in wrought light alloys have been summarised, and it remains now to mention the steps which may be taken to prevent further premature

failures of primary aircraft components due to directionality. In the Bristol Aeroplane Company the following system has been introduced for Class I parts (*i.e.* parts in a primary structure) fabricated in wrought light alloys.

1. Allowance is made for strength directionality and, for forgings or parts machined from forged stock, for achieved strength being lower than specification strength. With high working stresses drawings often need to specify the type of material to be employed, and the manner in which the part is to be extracted (this can be associated with the need to avoid the coarse grain envelope at the back ends of extruded lengths).
2. Allowance is made, where necessary, for *ad hoc* testing of a component, or for the extraction of suitable tensile specimens from the raw material, or the component.
3. All stress-raisers, such as holes and sharp changes of section are relieved so far as is possible, consistent with design requirements.
4. Allowance is made where necessary for the presence of locked up stresses which may be as high as, say, 7 tons/sq. in. in forgings or parts machined from large extrusions or forged stock. Little information is available as yet on this topic.
5. All drawings are examined individually by the technical organisation in co-operation with the design office and the planning department. Also, the material manufacturer is consulted for difficult applications so that his experience may be enlisted.*

It might be asked why all-metal aircraft have been built for many years without directionality troubles having previously given premature failures, and therefore without the need for this comprehensive system being applied to drawings of primary structural components. The answer lies mainly in the changes in aircraft design. As the all-up weight of an aircraft increases so must weight saving be more rigorously applied; this naturally leads to the use of more efficient structures and to higher working stresses, and to the use of larger sizes of raw material stock. Thus, simultaneously transverse loadings have been extended for reasons of structural efficiency and larger extrusions and forgings have been employed which are more liable to exhibit marked directionality, since the manufacturing size limitation is being approached.

ACKNOWLEDGMENTS

Thanks are due to the Bristol Aeroplane Co. Ltd., Aircraft Division, for permission to quote the test data employed herein, and for assistance in the preparation of the illustrations.

* Subsequent to the writing of this paper, A.D.M.622 has been revised, and for this and other reasons the system has been extended to include:

(*a*) Cut-up tension and/or *ad hoc* tests on all light alloy Class I forgings.

(*b*) Re-heat treatment after part machining of certain large components to improve strength properties (*i.e.* counteract "mass effect"), reduce machining distortion, and relieve locked-up stresses.

RESISTANCE-WIRE STRAIN GAUGES

by

J. G. STRONG, B.Sc., A.C.G.I., A.F.R.Ae.S.

INTRODUCTION

It is odd to think that the resistance-wire strain gauge could have been put to use some 40 years ago, about the time of the first filament-wire lamp and the thermionic valve. The physical principles involved were already known. Kelvin had measured the resistance of wires in tension, there were galvanometers in plenty, and even crude valve amplifiers existed. It only really remained for someone to put two and two together. Instead we had to wait until the necessity of stressed-skin construction forced the hand of the engineer into seeking a more effective method of strain analysis than the old empirical ways.

THE RESISTANCE-WIRE STRAIN GAUGE

What is a resistance-wire gauge? It consists of a thin filament of resistance wire, a few inches long, about one-thousandth of an inch in diameter, looped or coiled into the shape of a small, flat grid (Fig. 1). The grid is about half-an-inch in length, and is fastened with an adhesive cement to a small rectangle of thin paper. The ends of the wire have short copper leads spot-welded to them, and a covering layer of thin paper is pressed down on top, effectually sealing and bonding the gauge into a thin wafer.

To measure the stress or strain in a surface or structure, the gauge is first glued to a clean, prepared section, aligned in the right direction and allowed to dry hard. If the member to which the gauge is attached is now loaded under test, by nature it will increase or decrease in length by a very small amount and in doing so, force the resistance grid to stretch or foreshorten. The actual distortion may not be perceptible to the eye—perhaps less than a thousandth of an inch—but it is sufficient to alter the electrical resistance of the gauge by a proportional amount.

This electrical resistance change may be measured in a Wheatstone Bridge circuit which operates, say, a galvanometer spot-light, and by checking this deflection against a previously known strain calibration it is possible to state exactly the strain, or stress, in the metal immediately underneath the gauge.

In essence, this is the basic theory of the electrical resistance gauge. It transforms a physical change into an electrical magnitude; a sort of electrical microscope that works by remote control. Imagine trying to measure, by any other method, the expansion between two hair-lines on a jet-engined impeller rotating at 10,000 r.p.m. It is extremely doubtful if it could be done.

GAUGE SENSITIVITY

The physical phenomenon linking wire strain and resistance variation is still not properly understood. We only know that the percentage change of resistance is equal to the strain multiplied by a constant known as the Sensitivity Factor, *i.e.*

$$\Delta R/R = e.S.$$

By all the laws of nature, and Poisson's Ratio, this should be about 1.6 for an average metal. To illustrate the present uncertainty, no one can yet explain how this factor comes to vary from +5.7 for an alloy like iridium-platinum to −12.1 for pure nickel. The metallurgist has much to learn and explain away.

Prize-winning paper submitted for the Hatfield Branch Discussion Evening Competition, 1949.

Mr. Strong is a Section Leader in the Stress Office of the de Havilland Aircraft Co. Ltd., Hatfield.

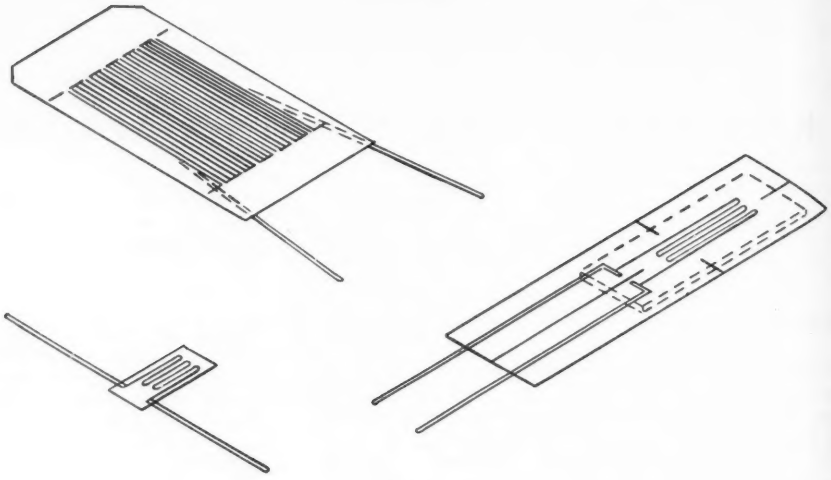


Fig. 1.

For general purposes, the wire used in strain gauges is a straightforward cupro-nickel, or nickel-chrome alloy, such as Eureka, Brightray, Nichrome. They have sensitivity factors of 2.0 – 2.3; their characteristics are well known, and they have proved reliable. There is a second class of wire, a heavily cold-worked elinvar alloy of nickel and iron, known as Isoelastic. It has a sensitivity factor of 3.5, which means it gives a 50 per cent. greater "signal" for a given strain and, moreover, it can work at temperatures up to 400° or 500°C., although recently Nichrome V has been used successfully at over 650°C.

TEMPERATURE COMPENSATION

The fact that resistance gauges can work at high temperatures invites the question as to how far the temperature expansion of a metal structure can falsify gauge readings, since obviously any change in the length of a member, whether mechanical or through heat, alters the gauge resistance.

In fact there are two temperature effects. First the specific resistance of the wire alters with temperature; second, there is the mechanical stretch depending on the difference between the expansion coefficients of the wire and the material to which the gauge is stuck.

For example, supposing the gauge were to be stuck to a bar of metal lying on the floor, completely unloaded, just warming up in front of a fire. The instruments would record a steadily increasing "apparent" stress as the bar grew hotter. There is no stress whatever in the bar if it expands freely of its own accord. If it happened to be a sheet of alclad, and the gauge was Nichrome, the fictitious stress recorded would be 450 lb./sq. in. for every degree centigrade rise. Quite enough to swamp true stress readings if it were allowed.

Happily the answer to this problem is conveniently simple. To measure the resistance change in a strain gauge the standard method is to incorporate it in one of the four resistance arms of a Wheatstone Bridge (Fig. 2). When the bridge is adjusted to balance no current passes through the galvanometer. Any temperature variation alters the gauge resistance, causing current to flow through the galvanometer, but by sticking a second strain gauge to a piece of unstressed metal of the same temperature, and connecting it to an adjacent arm of the bridge circuit, the bridge is kept in perfect balance. This is because both strain gauge and "dummy" gauge possess identical resistance changes whatever the temperature. Only a resistance change due to actual strain under the test gauge can throw the circuit out of balance, and this alone is measured.

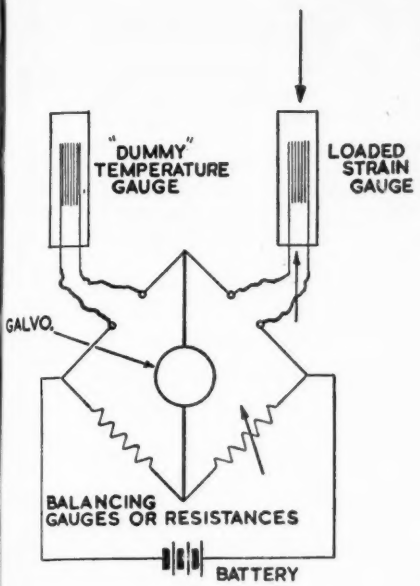


Fig. 2.

PREPARATION FOR A STRAIN GAUGE TEST

Turning now to the preparations for a strain gauge test and, incidentally, to the source of 90 per cent. of the trouble encountered, for not everyone is yet convinced of the reliability of such tests. There is an impression sometimes that strain gauges are slapped on with the same ease as stamps are stuck on an envelope, and then forgotten. But a large proportion of the poor results sometimes obtained from gauges can be directly traced to poor installation technique.

If first class results are wanted a good job must be done. The metal surface should be thoroughly cleaned with emery cloth and a degreasing agent, such as acetone or "thinners." In a factory there is always a thin layer of oil everywhere. It cannot be detected, but it is there, so for the final clean another dry cloth and more acetone should be used. The back of the strain gauge should be cleaned as well. The surface should not be touched again with fingers.

There are all sorts of adhesives that can be tried for sticking on strain gauges; glues, cold cements, hot cements, thermo-setting cements, and so forth, some good, some bad, and mostly indifferent. Choose a good one, a cold cement like Durofix, for example. Smear a little on the gauge, and press it firmly to the surface. Work it around a little with the fingers, and wipe away any surplus that squeezes out. Line it up in the right direction, and leave it severely alone for at least 24 hours. If it is stuck properly by then the point of a penknife should only be able to tear a small corner of the paper without damaging the gauge.

What is not wanted is a rubbery cushion of cement on which the gauge gently floats; the readings will be sheer nonsense.

While the gauges are drying out time can be filled in by running out several miles of wire in all directions. It is best not to solder the wires to the gauges until a fair number of people have observed what is being done, and have learned how to avoid tripping over them.

THE ELECTRICAL CIRCUIT

The electrical part of strain gauging can be divided roughly into three stages; a pre-circuit consisting of strain gauges and balancing resistances, an amplifying stage, and the recording gear.

For the pre-circuit there are two choices: a Wheatstone Bridge network, or a Potential Divider circuit (Fig. 3). The latter is used only for dynamic strain measurement but has the merit of being simple. The Wheatstone Net is the more universal pre-circuit.

Most people will recognise the Wheatstone Bridge as the old telegraphist's Post Office Box, except that the resistance variation of a strain gauge is so small that to try and measure it with this instrument would be like measuring the diameter of a hair with a foot-rule divided into tenths. I have already described what happens when the Bridge is unbalanced by an increase or decrease in resistance of one of the arms.

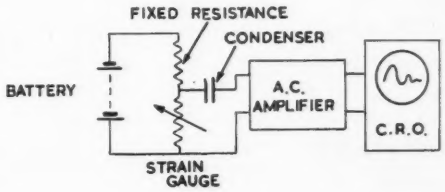


Fig. 3.

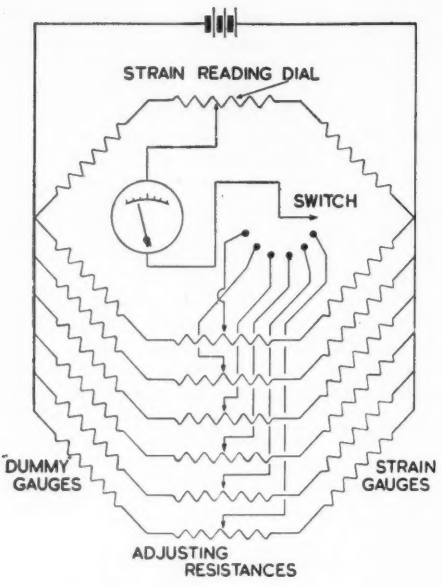


Fig. 4.

There are two ways of measuring the strain. Either the deflection of the galvanometer light-spot is read, or the bridge is re-balanced by hand and the amount of resistance is noted down which it is necessary to add or subtract to restore the galvanometer to the centre position. This is the " null point " system and is extremely accurate (Fig. 4).

This is the method used for operating a number of parallel strain gauges. The variable resistance is a vernier which can be calibrated to read directly the stress if desired. The switching is always done on the indicating, or galvanometer, side of the bridge and not in the main circuit. This is because the resistance of the switch contact varies every time and can be as much as the resistance change of the gauge that is to be measured. In the indicating circuit it has negligible effect.

INSTRUMENTATION

Instrumentation for both static and dynamic strain reading depends upon whether single- or multi-channel equipment will be required.

For static strains the simplest equipment is the hand-operated bridge just described, accommodating from six to a dozen gauges. For large numbers an electrically-switched automatic bridge is advisable, the readings being traced at the rate of about one every second by a pen-recorder. For still greater numbers, say for 100 to 600 gauges, the gauges are grouped in banks of eight, scanned by a rotating chopper switch, and their values flashed on to a cathode-ray screen eight at a time and photographed at high speed. Six thousand readings can come out of a ten minute test. There is plenty of time to work out the results later (Fig. 5).

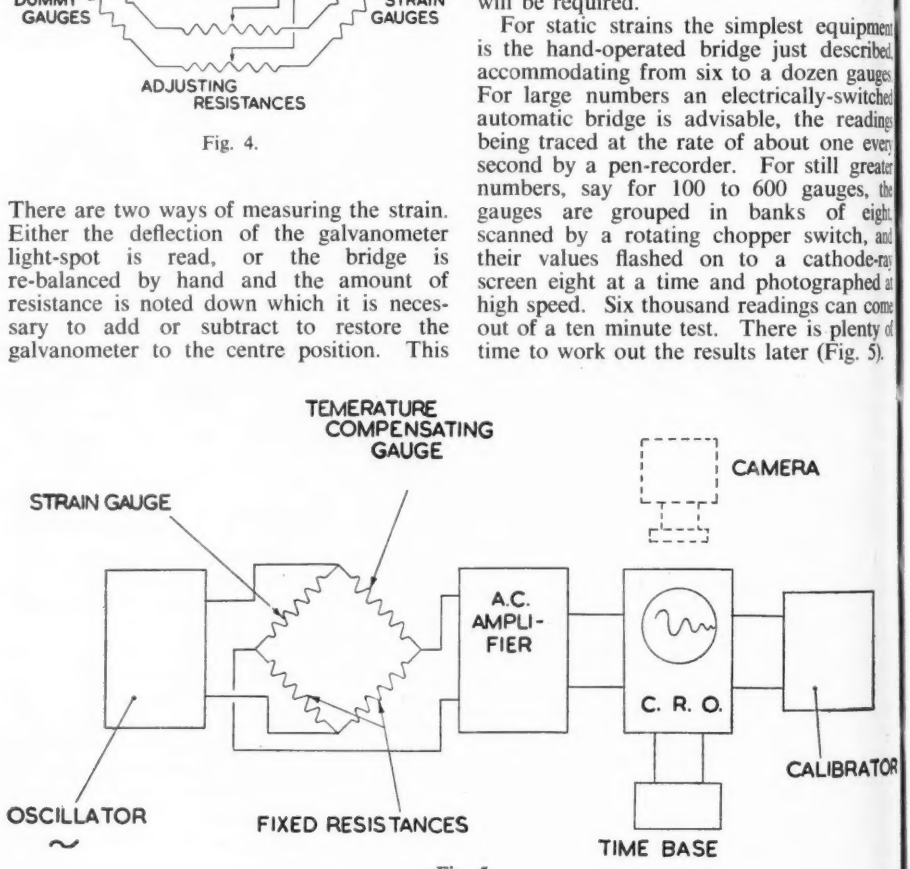


Fig. 5.

For dynamic strains, as in flutter research, or investigation of landing shocks, or the effects of gun blast, one is limited to a relatively small number of gauges, 12-16 at one time. This is because each gauge requires its own amplifier, the signals being fed to a bank of vibration galvanometers, each focusing a separate light trace over a moving film. A flashing time-base marker also prints on the record every fiftieth or hundredth of a second, and the roll is then developed in the usual way.

For ultra-high speed work, the cathode-ray tube is used exclusively, but one gauge, one tube, means that the number of gauges must be severely limited.

EQUIPMENT

The individual equipment used in strain gauging has to work to a far higher standard than is generally realised. The fidelity of the vision channel of a television receiver is the order of accuracy needed. Hence the cost.

Amplifiers have to be linear in response from zero to 10,000 cycles/sec.: they must be stable and free from drift over a reasonable period of time. There are also other requirements which are equally rigid. These are not so difficult to meet with A.C. amplification, since they are the same features met in ordinary radio; that is why A.C. energised bridges are often used, although they invite other difficulties which are absent in D.C. operation. D.C. amplifiers are relatively new in conception, and are not easy to stabilise, although progress is being made.

Early experimenters tended to favour the cathode-ray oscilloscope for all dynamic research, but nowadays the lightweight pen-recorder for fluctuating stresses up to 50 cycles per sec., and the vibration galvanometer for recordings up to 5,000 c.p.s., are leaving the cathode-ray tube only the top end of the frequency scale.

The electro-magnetic vibration galvanometer was invented 50 years ago by Duddell. It consists of a single loop of phosphor-bronze ribbon, stretched taut between the poles of a powerful magnet (Fig. 6). A small mirror is fixed to the two parallel ribbons and reflects a light-spot. The loop twists in the magnetic field in proportion to the current passing through it and, having very little inertia, it can follow faithfully the waveform of the current oscillation, the light-spot tracing the pattern on to a moving film.

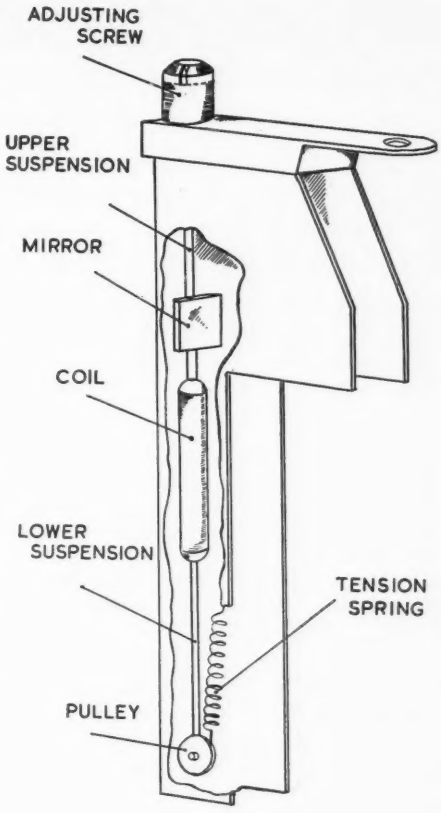


Fig. 6.

The pen-recorder is really a powerful galvanometer to which is attached an inking needle, something like that of an ordinary barograph, which traces the fluctuating strains on a long strip of moving paper. Newer designs have now appeared in which a high voltage applied to the pen sparks continuously through the moving paper, burning the trace into a chemically prepared surface (Fig. 7).

The cathode-ray tube is too well known to need describing. It presents on a screen a vertically moving spot of light whose amplitude is proportional to the strain in the gauge. I said previously, one gauge, one tube, but by using an electronic switch it is

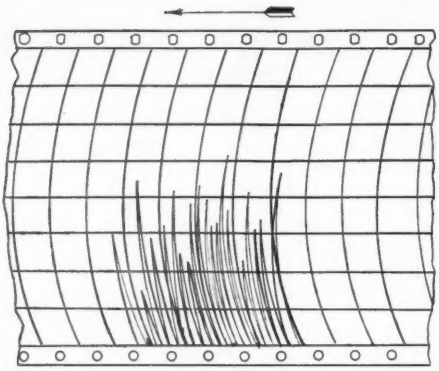


Fig. 7.

possible to reproduce two, or even four distinctly separate traces on one tube face. Mechanical chopping switches are also used when the rate of strain variation is reasonably slow.

Other specialised pieces of equipment are cameras, time-markers, accelerometers, vibration pick-ups, and so on.

CALIBRATION OF STRAIN GAUGE EQUIPMENT

The routine calibration of the complete equipment is essential since some items are inclined to vary. It can be done by means of two gauges stuck to a tension strip, which is then loaded with dead weights and the readings checked against the calculated true strain. Alternatively, a beam calibrator is used (Fig. 8). This is a rectangular bar of metal supported on knife edges and put in bending. The strain is then estimated from the measured deflection at the centre, and the bar is turned over to enable the equipment to be calibrated for both compressive and tensile strains.

ANALYSING THE RESULTS

The elements of strain analysis can be found in a textbook, so there is little object in mentioning them here. The strain gauge picks up only the components of strain that happen to lie along its longitudinal axis, whatever their origin. A single gauge in a complicated stress field therefore has a dubious value, unless its axis coincides with the axis of principal strain (Fig. 9).

Three gauges grouped in a combination known as a strain rosette are needed to sort out a complex stress field, but from their readings a complete picture can be deduced. Two gauges placed at right angles will suffice to measure the shear stress in the region, but nothing else. For analysing shear webs which are likely to buckle into tension fields, gauges must be stuck on both sides, back to back, and their mean readings used. If gauges are placed too near rivet holes they will pick up local stresses which falsify the general stress distribution.

The position in which gauges are stuck should be considered with care. The stresses obtained may not agree with theory, in fact they seldom do closely, but that is because the theories employed are primitive in comparison. The chance that a gauge will be put on the exact point where, theoretically, the structure should fail are as likely as winning a first dividend in a football pool. It is better to distribute the gauges so that a clear overall picture of the stress flow is obtained. In this way effective economy of design can subsequently be shown.

COMPUTING THE RESULTS

Tabulating and analysing gauge readings is a story in itself. Having successfully completed a test, the readings are triumphantly carried away to be analysed. Fifty gauges, say, have been used and the load was applied in 10 increments; six going up, and four as the load was released—500 readings in all. The load was run up twice,

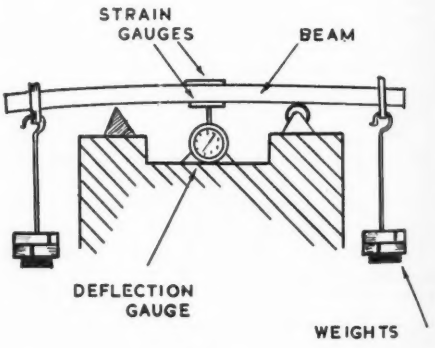
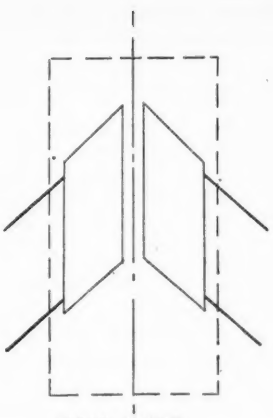
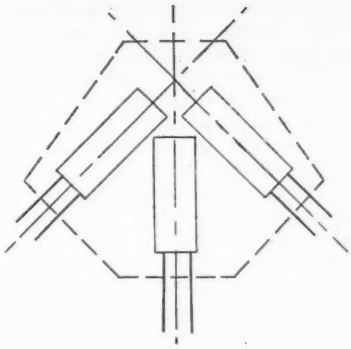


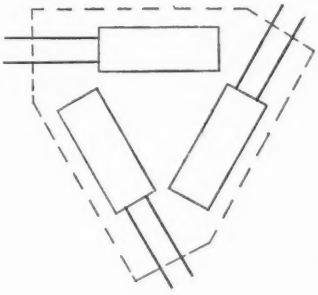
Fig. 8.



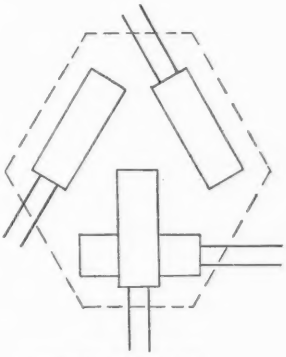
SHEAR GAUGE.



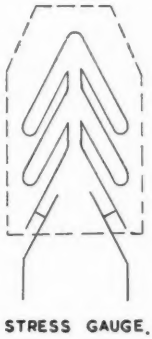
RECTANGULAR ROSETTE.



DELTA ROSETTE.



T-DELTA ROSETTE.



STRESS GAUGE.

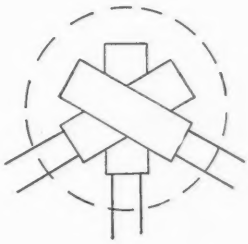


Fig. 9.

so for 20 minutes in its testing there are 1,000 separate figures. By the time 50 graphs have been plotted, their mean lines corrected, the principal stresses and directions worked out, little interest in the matter will be taken, whatever the result. Next time six gauges at the most will be considered quite enough.

However, there are tabular methods, special slide-rules, and other means for speeding up analysis. Perhaps the simplest is an electrical analyser; three dials are set to the three rosette strains, a button is pressed, and the answer read direct from a meter. If something still more elaborate is wanted, there is a cathode-ray version which works out the whole problem while the test is actually proceeding, and presents the solution pictorially on the screen. Unfortunately, it is expensive.

CONCLUSION

In concluding it can be said that the resistance strain gauge has come to stay, both in the structural laboratory and in the field, as a means of measuring physical force in remote positions, for giving warning of danger, and as an automatic means of operating safety devices. It requires no bolts or screws to hold it, its weight is negligible, and its size insignificant. It will improve and reach out far beyond present limitations, and it will be reliable. Reduce or eliminate the human failing in the technique and it will be perfect.

SUMMARY OF THE ACTIVITIES OF THE SOCIETY

JANUARY—DECEMBER 1949

THE CHARTER OF INCORPORATION

The Society was granted a Charter of Incorporation on the 17th January 1949. The full text of the Charter, together with a message from the President, was published in the February 1949 JOURNAL.

ANNUAL GENERAL MEETING

The Annual General Meeting of the Society was held on Thursday, 5th May 1949, in the offices of the Society.

PRESENT

Dr. H. Roxbee Cox (President) in the Chair.

Mr. J. Bell (Associate)
Sir John S. Buchanan (Fellow)
Major G. P. Bulman (Fellow)
Mr. V. R. Billings (Associate Fellow)
Mr. S. Camm (Fellow)
Mr. J. D. Campbell (Associate Fellow)
Mr. A. V. Cleaver (Associate)
Mr. A. B. Coates (Associate)
Mr. T. S. D. Collins (Associate Fellow)
Mr. C. Robson Elgie (Associate)
Mr. A. G. Elliott (Fellow)
Sir A. H. Roy Fedden (Fellow)
Professor A. A. Hall (Fellow)
Mr. I. O. Hockmeyer (Associate Fellow)
Mr. J. W. F. Housego (Graduate)
Mr. G. Ingram (Associate)
Mr. H. A. Jarrett (Associate Fellow)
Mr. Peter Masefield (Fellow)
Mr. L. Mawer (Associate Fellow)
Miss E. Merchant (Associate)
Mr. G. Newbery (Associate Fellow)
Mr. C. N. S. Pringle (Associate Fellow)
Mr. N. E. Rowe (Fellow)
Mr. S. J. Smith (Graduate)
Mr. R. S. Stafford (Fellow)
Lt. (Ae) J. Templeton (Associate)
Mr. W. Tye (Fellow)
Dr. H. C. Watts (Fellow)
Mr. J. H. W. Wheatley (Associate Fellow)
Mr. J. A. C. Williams (Associate Fellow)

In attendance: The Secretary and Miss Barwood.

---

1. The Secretary read the Notice convening the Meeting.
2. The Report of the Council on the state of the Society and the Balance Sheets of Aerial Science Limited and Aeronautical Trusts Limited for the year ended 31st December 1948 were presented and those members present were asked to make any comment they wished on the Report.

   No comments were forthcoming and the Report was Adopted by the meeting.
3. As a result of the Ballot the Secretary reported the following nominations to fill the vacancies on the Council:

   Mr. G. R. Edwards
   Sir A. H. Roy Fedden
   Sir Arthur Gouge
   Major F. B. Halford
   Mr. W. G. A. Perring
   Mr. N. E. Rowe
   Captain C. F. Uwins

4 The Secretary read the names of those proposed for Fellowship and passed by the Council as follows:

Edgar Hilton Atkin
James Valentine Connolly
Percy George Crabbe
Ivan Howard Driggs
Arthur Ernest Hagg
Robert Ernest Hardingham
Arthur Lorne James
Jules Louis Albert Jarry
William Henry Lindsey
John Lloyd
Elizabeth Muriel Gregory McGill
Basil Gervasse Markham
John Knudsen Northrop
David Macleish Smith
Richard W. Walker

5. It was agreed that Messrs. Price Waterhouse be reappointed Auditors for the ensuing year for Aerial Science Limited and Aeronautical Trusts Limited.

The Meeting then terminated.

SPECIAL GENERAL MEETING

A Special General Meeting of the Society was held on Thursday, 5th May 1949, in the offices of the Society, at which the following members were present:

Dr. H. Roxbee Cox (President) in the Chair.

Mr. C. M. Barter (Associate Fellow)
Mr. J. Bell (Associate)
Mr. V. R. Billings (Associate Fellow)
Mr. J. R. Booth (Associate)
W/Cdr. R. A. C. Brie (Associate Fellow)
Mr. A. MacNiven Brown (Associate Fellow)
Major G. P. Bulman (Fellow)
Mr. S. Camm (Fellow)
Mr. J. D. Campbell (Associate Fellow)
Miss L. Chitty (Fellow)
Mr. A. V. Cleaver (Associate)
Mr. A. B. Coates (Associate)
Mr. S. G. Ebel (Fellow)
Mr. G. R. Edwards (Fellow)
Mr. C. Robson Elgie (Associate)
Mr. A. H. Fear (Associate Fellow)
Mr. I. O. Hockmeyer (Associate Fellow)
Mr. N. J. Hancock (Associate Fellow)
Mr. C. D. Holland (Fellow)
Mr. J. W. F. Housego (Graduate)
Mr. G. Ingram (Associate)
Mr. H. A. Jarrett (Associate Fellow)
Air Cmdre. D. F. Lucking (Fellow)
Mr. P. Masefield (Fellow)
Mr. L. Mawer (Associate Fellow)
Miss E. Merchant (Associate)
Mr. G. Newbery (Associate Fellow)
Mr. W. G. A. Perring (Fellow)
Mr. F. J. Pierce (Associate Fellow)
Prof. A. G. Pugsley (Fellow)
Mr. N. E. Rowe (Fellow)
Mr. W. P. Savage (Fellow)
Mr. N. Simmons (Associate Fellow)
Mr. P. L. Sumner (Associate Fellow)
Lt. (Ae) J. Templeton (Associate)
Mr. W. Tye (Fellow)
Dr. H. C. Watts (Fellow)
Mr. J. H. W. Wheatley (Associate Fellow)
Mr. J. A. C. Williams (Associate Fellow)
Mr. C. G. A. Woodford (Associate Fellow)
Mr. J. E. Walker (Associate Fellow)
Mr. K. W. B. Fouweather (Associate)

In attendance: The Secretary and Miss Barwood.

---

1. The Secretary read the Notice convening the Meeting.

2. The following Resolution was proposed by Dr. H. C. Watts (Fellow) and seconded by Mr. N. E. Rowe (Fellow):—

"That this meeting adopts the revised By-laws proposed by the Council of the Society as the By-laws governing the Society."

The Resolution was passed unanimously.

SPECIAL GENERAL MEETING

A Special General Meeting of the Society was held on 9th December 1949, in the offices of the Society, at which the following members were present:

Sir John Buchanan, Fellow (President) in the Chair.

Mr. C. F. Andrews (Associate)
Mr. J. Bell (Associate)
Mrs. J. Bradbrooke (Associate)
Prof. A. R. Collar (Fellow)
Mr. N. Hancock (Associate Fellow)
Mr. G. Ingram (Associate)
Mr. B. Jablonski (Associate Fellow)
Dr. D. M. A. Leggett (Associate Fellow)
Air Cmdre. D. F. Lucking (Fellow)
Mr. I. L. A. McNicol (Associate)
Mr. H. A. Marsh (Associate Fellow)
Mr. A. Muraszrew (Associate Fellow)
Mr. N. E. Rowe (Fellow)
Mr. D. C. Smith (Associate Fellow)
Mr. S. Smolemiec (Associate Fellow)
Air Cmdre. J. H. C. Wake (Associate Fellow)
Mr. R. R. Walls (Associate Fellow)
Dr. H. C. Watts (Fellow)
Mr. L. A. Wingfield (Associate)

In attendance: The Secretary.

1. The Secretary read the Notice convening the Meeting.
2. Mr. N. E. Rowe, Fellow, proposed, and Mr. G. Ingram, Associate, seconded the motion that the Meeting confirm the following Resolution of the Council passed on the Twenty-ninth day of September 1949.

"Resolved that Clause 4 of the Charter of the Society be amended as follows:—

(I) In sub-clause (*i*): by deleting the word 'Petition.'

(II) In sub-clause (*j*): by inserting the word 'Charitable' before the word 'associations' where the word first appears.

(III) By deleting sub-clause (*k*) and substituting the following in lieu thereof: '(*k*) to found, establish, undertake, superintend, administer and contribute to the support of educational institutions, schools and classes and any charitable funds conducive to the objects of the Society.'

(IV) In sub-clause (*l*): by adding the following words at the end of the said sub-clause: 'Provided always that no part of the property or funds of the Society shall be applied for other than charitable objects.'"

The Resolution was passed unanimously.

THE SECOND INTERNATIONAL AERONAUTICAL CONFERENCE

The Second International Aeronautical Conference was held in New York under the auspices of the Institute of the Aeronautical Sciences from 23rd May to 3rd June 1949. The President, Sir John Buchanan, and the Secretary, Captain J. Laurence Pritchard, together with some 60 members of the Society attended the Conference.

Delegates assembled in New York on the 23rd May and the official opening of the Conference was marked by a reception at the headquarters of the Institute of the Aeronautical Sciences.

The three-day Technical Sessions, at which 22 papers were read, were held at the Hotel Astor,.

The Conference ended with an official reception and dinner on 26th May, attended by some 500 members of the Institute and the British delegates. The President of the Institute, Mr. W. A. Burden, welcomed the guests and proposed the toast of the Society, to which Sir John Buchanan, President, replied. Sir Frederick Handley Page, Past-President of the Society, also spoke. The dinner was marked by the presentation to Dr. Igor I. Sikorsky of the Society's Silver Medal and the presentation of Honorary Fellowship of the Institute to Captain J. Laurence Pritchard, Secretary of the Society.

Following the Technical Sessions there were a number of social functions arranged by the Institute and its members, and visits were made by most of the British delegates to a number of American aircraft and engine firms and to official establishments. The delegates were flown from La Guardia Field, New York, to Washington in an American Airlines DC-6; from Washington to Langley, Virginia, by the U.S. Air Force Military Air Transport Service in a C-97 Boeing Stratocruiser, spending the night at Williamsburg; and from Langley Field to Patuxent River Md., in R 4Ds of the U.S. Navy, and from Patuxent to Philadelphia and back to New York.

At the end of a strenuous two weeks' programme the officers and Council of the Institute gave a farewell dinner to the British guests at Rockefeller Centre.

The following is a list of the papers given at the Technical Sessions and the visits made:—

Tuesday, 24th May

Morning Session, 9 a.m.

Chairman: E. S. Taylor, Professor of Aircraft Engines, M.I.T.

Opening remarks by the Presidents of the Institute of the Aeronautical Sciences and the Royal Aeronautical Society—Mr. W. A. Burden and Sir John Buchanan.

Optimum Fields of Application for Air-Consuming Aircraft Power Plants—W. G. Lundquist and G. S. Kelley.

The Propeller Gas Turbine in Service—F. M. Owner.

Recent Design Refinements in Turbojet Engines—N. Burgess and J. C. Buechel.

Luncheon, 12.30 p.m.

Guest Speaker: T. P. Wright, Vice-President—Research, Cornell University.

Afternoon Session, 2 p.m.

Chairman: Robert M. Stanley, President, Stanley Aviation Corp.

Turbine-Engined Transport Aircraft—G. R. Edwards.

Research on Helicopters at the R.A.E. with Special Reference to the Stability of Multi-rotor Helicopters—H. B. Squire.

Operation Whirlwind—Past, Present, Future—C. M. Belinn.

Wednesday, 25th May

Morning Session, 9 a.m.

Chairman: C. C. Furnas, Dir., Cornell Aeronautical Laboratory, Inc.

Aircraft Materials from the Designers' Point of View—A. E. Russell.

The Application of Materials from the Manufacturers' Point of View—P. L. Teed.

Materials in the Aircraft Industry—Clyde Williams.

Luncheon, 12.30 p.m.

Guest Speaker: Grover Loening, Consultant, N.A.C.A.

Afternoon Session, 2 p.m.

Chairman: Joseph S. Newell, Prof. of Aero. Structural Eng., M.I.T.

Aeroelastic Problems at Supersonic Speeds—A. Flax.

The Life of Aircraft Structures—H. A. Wills.

American Structural Design Trends—G. G. Green.

Evening Session, 8 p.m.

Chairman: C. H. Colvin, Vice-President, G. M. Giannini and Co., Inc.

The Relative Merits of Auxiliary Power Systems—The Hydraulic Aspect—H. G. Conway.

The Relative Merits of Auxiliary Power Systems—The Electrical Aspect—R. H. Woodall.
The Relative Merits of Auxiliary Power Systems—The Pneumatic Aspect—H. R. Haerle.
Aerodynamically Boosted Surface Controls and Their Application to the DC-6 Transport—O. R. Dunn.

Thursday, 26th May

Morning Session, 9 a.m.

Chairman: Francis H. Clauser, Chairman, Aeronautics Department, The Johns Hopkins University.
Comparison Between Theory and Experiment for Wings at Supersonic Speeds—Walter Vincenti.
Some Considerations of the Flutter Problems of High-Speed Aircraft—E. G. Broadbent.
Flight Research at Transonic and Supersonic Speeds with Free-Falling and Rocket-Propelled Models—Floyd L. Thompson.

Luncheon, 12.30 p.m.

Guest Speaker: Capt. J. Laurence Pritchard, Secretary, Royal Aeronautical Society.

Afternoon Session, 2 p.m.

Chairman: William Littlewood, Vice-Pres. Engineering, American Airlines.
The Relative Efficiencies of Large Landplanes and Flying Boats—D. Keith-Lucas.
Aerodynamic Efficiencies of Large Landplanes—G. S. Schairer.
Operating Factors Affecting the Design of Future Civil Transport Aircraft—Christopher Dykes.
Utilisation Factors and Maintenance of Civil Aeroplanes—Warren Alberts.

Evening

Second International Conference Dinner, 7.30 p.m.

VISITS

Friday, 27th May

Tour of Grumman Aircraft Engineering Corporation, Republic Aircraft Corporation and the Ranger Aircraft Engine Division of Fairchild Engine and Airplane Corporation (including a tour of the Stratos Corporation and Al-Fin divisions of Fairchild) on Long Island.

Saturday, 28th May

Demonstration of the Sperry Blind Landing System at McArthur Field, Long Island.

Buffet Luncheon and Flying Garden Party at the Aviation Country Club, Hicksville, Long Island.

Reception and Buffet Dinner given by Mr. Grover Loening at Mill Neck.

Sunday, 29th May

Luncheon and Garden Party given by Mr. Earl D. Osborn, President of the Edo Corporation, at Garrison, New York. This included a visit to the U.S. Military Academy at West Point.

Monday, 30th May—U.S. Memorial Day

Luncheon and Garden Party at "Florham," Convent, N.J., the home of Miss R. V. Twombly, aunt of Mr. W. A. Burden.

Tuesday, 31st May

Start of Circle Tour to Washington. Inspection of the Military Air Transport Service (U.S. Air Forces) at Andrews Field. Sightseeing tour of Washington.

Reception by the State Department, followed by dinner at the Mayflower Hotel arranged by the Washington Section of the Institute.

Wednesday, 1st June

Inspection of National Advisory Committee for Aeronautics laboratories and wind tunnels at Langley Field.

Thursday, 2nd June

Inspection of Naval Air Station at Patuxent River, Md., including a demonstration of flight testing and experimental facilities. Visit to the Naval Air Material Centre at Philadelphia. Return to New York.

Friday, 3rd June

Visits to the Wright Aeronautical Corporation factory at Wood-Ridge, New Jersey, and the Curtiss-Wright Propeller Division at Caldwell, New Jersey.

Farewell Dinner—Rainbow Room.

Saturday, 4th June

Visit to the Navy Special Devices Centre, Sands Point, Long Island, and the Pan-American Airways Crew Trainer Centre.

The following is a list of the British delegates and members of the Society who were members of the Conference.

Argyris, J. H., A.F.R.Ae.S., Technical Staff, R.Ae.S.

Baker, H. P., Ministry of Supply; Bass, E. L., F.R.Ae.S., Chief Engineer, Aviation Department, Shell Petroleum Company Ltd.; Broadbent, E. G., A.F.R.Ae.S., Structures Department, R.A.E.; Bradbrooke, Mrs. J., A.R.Ae.S., Editor, R.Ae.S.; Buchanan, Sir John, F.R.Ae.S., President, R.Ae.S.

Chaplin, Roland H., F.R.Ae.S., Assistant Chief Designer, Hawker Aircraft Ltd.; Clarke, J. S., Head of Research Section, Joseph Lucas; Clarkson, C., A.F.R.Ae.S., Civil Air Attaché, British Embassy; Constant, H., F.R.Ae.S., Director, National Gas Turbine Establishment, Ministry of Supply; Conway, H. G., F.R.Ae.S., Technical Director, British Messier Ltd.; Crewe, P. R., A.F.R.Ae.S., Aeronautical Technician, Saunders-Roe Ltd.

Davidson, E. G., Companion R.Ae.S., Anglo-Iranian Oil Co. Ltd.; Davies, Handel, F.R.Ae.S., Aero Flight Department, R.A.E.; Douglas, G. P., F.R.Ae.S., Aerodynamics Department, R.A.E.; Dykes, Christopher, A.F.R.Ae.S., Deputy Chief Project Engineer, B.O.A.C.

Edwards, G.R., F.R.Ae.S., Chief Designer, Vickers-Armstrongs Ltd.

Faggetter, E. F., Esq., Dunlop Rubber Australia Ltd.

Gibson, W/C D. A., A.F.R.Ae.S., Air Material Command.

Hadfield, Peter, Assistant Civil Air Attaché, British Embassy; Haerle, H. R., Chief Technician, The Hymatic Engineering Company Ltd.; Hall, A. A., F.R.Ae.S., Professor, Imperial College; Handley Page, Sir Frederick, Hon. F.R.Ae.S., Managing Director, Handley Page Ltd.; Hilton, W. E., A.F.R.Ae.S. (Johns Hopkins, U.S.A.); Hollis-Williams, D. L., F.R.Ae.S., Chief Engineer, Fairey Aviation Co. Ltd.

James, Thurstan, Editor, *Aeroplane*; Jones, E. T., F.R.Ae.S., Director, Research and Development (Instruments), Ministry of Supply.

Keith-Davies, E., A.F.R.Ae.S., Director, Cambrian Airways; Keith-Lucas, D., F.R.Ae.S., Chief Designer, Short Brothers & Harland Ltd.; Kerr, C. E., British Joint Services Mission.

Lee, G. H., F.R.Ae.S., Chief Aerodynamicist and Chief of Research, Handley Page Ltd.; Leggett, D. M. A., A.F.R.Ae.S., Deputy Secretary, R.Ae.S.; Lombard, A. A., A.F.R.Ae.S., Chief Designer (Projects), Rolls-Royce Ltd.

MacGregor, E. I. R., Assistant Civil Air Attaché, British Embassy; McAlphine, G., F.R.Ae.S., Technical Advisor and Manager, Kelvin Bottomley & Baird Ltd.

Ogston, A. R., A.F.R.Ae.S., Esso Export; Owner, F. M., F.R.Ae.S., Chief Engineer (Engines), Bristol Aeroplane Company Ltd.

Pardoe, J. G. M., A.F.R.Ae.S., Design Staff, Air Registration Board; Petty, G. E., F.R.Ae.S., Chief Designer, Blackburn Aircraft Ltd.; Pribram, E., A.F.R.Ae.S., Technical Staff, R.Ae.S.; Pritchard, J. Laurence, Hon. F.R.Ae.S., Secretary, R.Ae.S.

Radcliffe, F., F.R.Ae.S., Technical Assistant to Sir Frederick Handley Page; Reissner, E., A.F.R.Ae.S., Research Engineer, Factories Direction Ltd.; Richards, E. J., A.F.R.Ae.S., Chief Aerodynamicist, Vickers-Armstrongs Ltd.; Richardson, C. A., A.F.R.Ae.S., Sales Engineering Manager, Sperry Gyroscope Company; Russell, A. E., F.R.Ae.S., Chief Designer (Aircraft), Bristol Aeroplane Company Ltd.

Scott-Hall, S., F.R.Ae.S., Director-General of Technical Development (Air) M.O.S.; Serby, J. E., F.R.Ae.S., Director of Military Aircraft Research Department, R.A.E.; Spurr, W. F., F.R.Ae.S., British Joint Services Mission; Stranks, Joseph D., A.F.R.Ae.S., Chief Experimental Engineer, Hawker Aircraft Ltd.; Squire, H. B., F.R.Ae.S., Aerodynamics Department, R.A.E.; Summers, M., A.R.Ae.S.

Taylor, J. Lockwood, A.F.R.Ae.S., Professor of Aeronautics, Istambul Teknik University, Turkey; Teed, P. L., A.F.R.Ae.S., Deputy Head of Aeronautical Research and Development, Vickers-Armstrongs Ltd.

Uwins, C. F., F.R.Ae.S., Director (Aircraft), Bristol Aeroplane Company Ltd.

Walmsley, R. H., F.R.Ae.S., Director of Aircraft Requirements, Ministry of Civil Aviation; Whiteley, E. A., Wing Commander, A.F.R.Ae.S., R.A.F., Air Ministry; Wilde, Geoffrey, A.F.R.Ae.S., Chief Experimental Compressor Section, Rolls-Royce Ltd.; Williams, J. K., A.F.R.Ae.S., Technical Surveyor, Air Registration Board; Wills, H. A., F.R.Ae.S., Council for Scientific and Industrial Research, Australian Government Department of Supply; Wills, G. W. A.F.R.Ae.S., Winterisation Experimental Establishment, M.O.S.; Wingfield, L. A., A.R.Ae.S., Solicitor, R.Ae.S.; Winny, H. F., F.R.Ae.S., Fairey Aviation Ltd.; Woodall, R. H., A.F.R.Ae.S., Chief Engineer, Rotax Ltd.; Woodward-Nutt, A. E., F.R.Ae.S., Director of Civil Aircraft Research and Development, M.O.S.

Following the Conference the President and Secretary of the Society together with the Deputy Secretary, spent a few days in Canada, visiting Toronto, Montreal and Ottawa. In Toronto they visited the factories of the de Havilland Aircraft Company Ltd., and A. V. Roe (Canada) Ltd., and dined with members of the Society in Toronto. While in Montreal they were guests at a cocktail party given by Sir Frederick Tymms, Fellow of the Society and United Kingdom Council Member of I.C.A.O., and of Dr. Edward Warner, Hon. Fellow of the Society and President of the Council of I.C.A.O.

In Ottawa the President, Secretary and Deputy Secretary met members of the Ottawa Branch of the Society, by whom they were most hospitably entertained, and visited the Canadian Government Air Centre at Rockcliffe.

HONOURS

The following members of the Society received awards in 1949:—

NEW YEAR HONOURS—JANUARY 1949

G.C.B. (*Civil*)

Sir Henry Tizard, K.C.B., A.F.C., F.R.S. (Fellow).

C.B. (*Military*)

Air Commodore A. W. B. McDonald, A.F.C., B.A. (Associate Fellow).
Major-General H. J. Parham, D.S.O. (Companion).

C.B.E. (Civil)

Major K. M. Beaumont, D.S.O., M.A. (Associate Fellow).
Mr. W. C. Devereux (Fellow).

O.B.E.

Mr. H. R. Gillman (Associate Fellow).
Mr. J. Wright (Fellow).

M.B.E.

Mr. D. W. Richardson (Associate Fellow).

Commendation for Valuable Service in the Air

Lt. Commander E. M. Brown, O.B.E., D.S.C., A.F.C., M.A. (Associate).

BIRTHDAY HONOURS

K.C.B.

Air Chief Marshal Sir James Robb, K.B.E., C.B., D.S.O., D.F.C., A.F.C. (Associate Fellow).

C.B.

Mr. W. G. A. Perring (Fellow).

O.B.E. (Civil Division)

Mr. J. S. Clarke, Ph.D., D.Sc. (Associate Fellow).

O.B.E. (Military Division)

Group Captain G. Silyn-Roberts, A.F.C., M.Sc. (Fellow).

King's Commendation for Valuable Service in the Air

Engineer 1A G. N. T. Hemmings (Student).

Other honours conferred on members during the year included the following:

Professor S. Goldstein (Fellow)—Fellow of the Institute of the Aeronautical Sciences.

Captain J. Laurence Pritchard (Hon. Fellow)—Honorary Fellow of the Institute of the Aeronautical Sciences.

Sir Ben Lockspeiser (Fellow)—Fellow of the Royal Society.

Mr. Denis Howe (Graduate)—Hele-Shaw Prize and Medal for 1948 awarded by the Institution of Mechanical Engineers.

ELECTION OF PRESIDENT AND VICE-PRESIDENTS

Sir John S. Buchanan, Vice-President, was elected President of the Society for the year 1949-50 at the Council Meeting on 31st March 1949, and took office at the meeting on 12th May 1949.

The following were elected Vice-Presidents of the Society for the year 1949-50 at the Meeting of Council held on 12th May 1949:—

W. G. A. Perring, Esq., F.R.Ae.S.
N. E. Rowe, Esq., C.B.E., B.Sc., D.I.C., F.R.Ae.S.
Dr. H. C. Watts, M.B.E., M.Inst.C.E., F.R.Ae.S.

ELECTIONS OF NEW MEMBERS AND TRANSFERS OF MEMBERSHIP

JANUARY 1949

Associate Fellows

Peter Llewellyn Bisgood, Kenneth Francis Brading (from Student), Wilfred Henry Bunting, Stacey Walter Drury Colls, Hugh Haslett Eccles (from Graduate), Edward Eric Fenn, John Fletcher, Ronald Fowkes (from Graduate), Charles

Gurney, Leslie Austin Hancox (from Associate), Emlyn George Havard (from Graduate), Ronald Edwin Victor Hawker, William Alfred Hibbert, David Ivan Hunt, Edgar Harold Jenkins, Jacques Alecxis Kirk (from Associate), Aubrey Frederick Walter Langford, Roy Henry Laver (from Associate), Tung Chi Lin (from Graduate), Llewellyn Lloyd-Davies, Imaduddin Mohammad Khan Malik, John Mulligan (from Associate), Daniel John McDonald, Vernon Dalrymple Naylor (from Graduate), William Thomas Nicholls, Peter Ovadias, Stanislaw Edmund Pozowski (from Associate), Dennis Martin Sealey, Donald Stanley Snow, Colin George Stocker, Philip Litherland Teed, James William Richards Twyman (from Graduate), Robert Philip Urry, Robert Thomas Wall (from Graduate), Joseph Wilkinson (from Associate).

Associates

Douglas Giosue Andreoli, William Leslie Berridge, Aubrey Charles Ericsson (from Student), Geoffrey Ivo Gregson, Roger Francis Deans Harris, Ronald Douglas John Hawkes, Leslie Bailey Hewett, Ronald Charles Jude, Piotr Ostaszewski-Ostoja, Hugh Dyas Parr, Edward Joughin Sheeran, Wilfred Ernest Streete, Alistair Macaulay Stephen, John Francis Walsh, Geoffrey Cyril David Warren, Charles Frederick Wills, Ivor Edward Yeates.

Graduates

Douglas Raymond Andrews (from Student), Peggy Irene Frances Bright, Peter Denis Burnett, Lewis Frederick Crabtree, Edward Melbourne Dallimore (from Student), Raymond William Dyke, Colin Faulkner, Terence John Floyd, Dorothy Ida Gwynne, Stuart Charles Haynes (from Student), Donald Malcolm Heughan (from Student), Denis Howe (from Student), Reginald Wallace Langmead, Gideon Maidanik, David Michael Mayne, John Francis Mew (from Student), Douglas Moore (from Student), Ivor Edward Moss, Gilbert Rugg Nicolson, John Rex (from Student), Tecwyn Roberts, Josephine Salmon, John Shackell, Victor Roy Gordon Smith, Graham Neil Stevens, Jerzy Terajewicz (from Student), Alan William Thompson, William John Trotman, Harry Wigman.

Students

John George Austin, Beryl Edna Beadle, Stanley Forsyth Borrie, Roy Burley Chesterton, Maurice Hubert Reginald Clark, Edward George Clegg, Geoffrey Montague Coiley, Donald Stephen Dugdale, Richard John Herbert, Michael Stewart Igglesden, Peter Norman Eckford Jones, Peter Frederick Keeling, Ronald William Prizeman, Harry Nigel Saint, Geoffrey Phillip Ashton Scovell, Richard Alan Sperry, Henry Edward Swann, John Bernard Sparling Prothero Thomas, Laurence David Tye.

Companions

Reuben Druce, Ivor Clarence Rogers, John Gerald Simms, Ladislav Vostatek, Rioty Marshal Winter.

FEBRUARY 1949

Associate Fellows

Ganesh Balkrishna Bhide (from Associate), Royston Bradshaw, Arthur Herbert Thomas Brazier (from Associate), Ernest James Brunckhurst (from Associate), Eric Harold Coleman (from Associate), Bernard Crossland (from Graduate), Ernest George Currington, Reginald Charles William Eyre (from Graduate), Richard William George Gandy, Jack Raymond Green, Richard Greinacher, Sidney Clifford Bernard Hailey (from Graduate), John Michael Harrison, Edward John Hidson (from Graduate), Albert Teichmann Howell (from Associate), Bengt Folke Jakobsson, Ronald Leslie Lawrence, Norman Hugh Le Gallais (from Graduate), Arthur Henry Logan, Konstanty Macewicz, Charles Oran Maliphant, Gordon Charles Montague Parris (from Student), Philip William Pilkington (from Graduate),

Reginald Charles Sanders (from Student), Norman Francis Searle (from Graduate), Stanley Arthur Stephenson (from Student), Romuald Szukiewicz, Jan Tustanowski, Jeffrey Watkins, Hugh Joseph Wilson (from Associate), David John Wright, Philip Wyndham Wright.

Associates

Geoffrey Cyril Ames, Raymond Percy Bench, Gabe Robb Bryce, Raymond Rupert Cavaney (from Student), Alfred Edward Charles Coward, Gordon Leonard Derham, John Edgeley, John Sinclair Gibbs, Stanley Heath, Donald Angelo Hewetson, James Horbury, Frederick William Howlett, Geoffrey Cecil Tudor Jones, Thomas Walker Kennedy, Lewis Eric Lang, John Kenneth Marshall (from Student), Edward Alexander Layton, John Richard Neill, Frederick Ewart O'Leary, George James Pearn, Peter George Randell, Harry Christian Salmon, Charles William Edward Ward, Sidney Charles Wybrow.

Graduates

Albert William James Adams, Donald Cyril Bain, Paul John Bellerby (from Student), Peter Lawrence Britton (from Student), Michael Broad, Alan Richard Buley, Michael Frederick Burle (from Student), Lawrence Wilfred Chambers, Kevin Edmund Cheverton (from Student), Raymond Close, John Lewis Cutler (from Student), Alan Russell Dare, David Richard Dennis, John Steward Drabble (from Student), Peter Reginald Dymond, Hugh Oliver Ewart (from Student), Arthur Horace Sidney Fernando, Terence John Floyd (from Student), Peter Harold Fredericks, Patrick William Joseph Fullam, Ian Alexander Butler Gaunt (from Student), John Gilchrist, John Colin Green (from Student), Jean Michael Hahn (from Student), Peter William Gerrett Hargreaves (from Student), Roy George Harmer (from Student), Peter Kenneth Hickman, John Edward Howland (from Student), Edward Vernon Hullah (from Student), Gerald David Macdonald (from Student), Frank Ronald Mason (from Student), Derek George Mitchelson, Samuel Edward Nelson, Leonard Eric Norton, Donald George Pearce (from Student), Peter Edward Radcliffe (from Student), William Harper Sleigh (from Student), Reginald Ernest Swinfield, Ronald Albert Swinnerton (from Student), Alwyne Edward Thornton (from Student), Albert William George Utting (from Student), Peter Herbert Stringer Wroe.

Students

Raymond Francis Anderson, Patrick Edward Stanbrook Batey, Peter Stanley Beckett, Michael Alan Blaxill, John Alan Caister, William Edward Thomas Cawsey, Graham Dudley Clapp, David Gordon Clark, Derek John Freeman, James Walter Gearing, Michael Eveness Haldane Grant, H. Ronald Harrison, Keith James Henderson, John Dennis Hodge, Ronald George Hudson, Peter Lionel Hughes, John Arthur Beverley Lambert, Peter Marsden, Jack Mawer, Donald George Merchant, Norman James Munro, Brian William Plenderleith, Primo Angelo Lazaro Signorini, Keith Welton Smith, Wallis Parkinson Stack, Saied Zafar.

Companion

Mary Theodora Peggy Ward (from Student).

MARCH 1949

Associate Fellows

Robert Hastings Adams (from Graduate), Peter Robert Allison (from Graduate), Leslie William Buckler, William Francis Cope, John Christopher Dykes, Dennis Thackray Fisher, Alan Henry Griffiths (from Student), Lionel Haworth, Alastair Michael Adair Majendie, Thomas Harold Mercer, Peter George Mobsby (from Graduate), John Mowbray Morton (from Graduate), Frank William Reed, Robert George Robertson, Haim Daniel Tabakman, David Walker (from Student), Ronald White Webster (from Graduate), George William Matthys Williamson, George Albert Woolvet (from Graduate).

Associates

Ronald Stanley Bradshaw, Pedro Jose Maria d'Avillez, Harold Frearson, James Arthur Randle Kay, Gabriel Lancaster, Ranald Logan Porteous, William Dennis Seabrook.

Graduates

Peter James Ballard, Thurstan Haddon Banister (from Student), Philip Gordon Binns (from Student), Anthony Frank Boot, John Charles Cooper (from Student), Graham Hopkins Davies (from Student), Douglas William Eggleton, Brian Robert Foord, Herbert Roy Hadley (from Student), Oliver William Charles Harris, Dennis Stanley Houghton (from Student), Philip Auriel Edgar Jeffrey, Arthur Albert Keeler (from Student), Haydn Sidney Liner (from Student), John Robert Linge, Dennis Albert Logan, William McIlroy (from Student), Dennis Roland Mear, Donald Blan Minterne (from Student), Ray Mohindra, Leonard Kenneth Cyril Packham, David John Perry, Harold Yeoman Ratcliffe (from Student), Duncan Menzies Soutar Simpson (from Student), Jasper Morris William Steer (from Student), Gordon Josiah Wedgwood, Raymond George Welcomme, George William Woods (from Student), Joseph Charles Wordsworth.

Students

Peter John Chance, John Cyril Chaplin, John Edward Crane, Gordon Esilman, Maurice Alfred Gee, Charles Forrest Graham, John Spreckley Hardiman, Derek Howarth, Frank Jackson, Arthur Albert Jacobs, John Michael Storer Keen (from Companion), John Drake Langdon, Johannes Lie, Peter Beaumont Morice, John Edward Nethaway, John Nickels, Roderic Timothy Pearse O'Shea, William James Redstone, Bernard Leslie Russell, Geoffrey Gordon Semark, James Charles Simpson, John Arthur Stafford, George Gordon Stuart, Brendan Patrick Thompson, Jeffrey Tinkler, Roland James Van Haefton, David Worth Wall, John Strange Wilson.

Companion

Ernest William Lucy.

APRIL 1949

Associate Fellows

Eric Rae Alexander, Sidney Allen, Arthur William Babister, Edward Granville Broadbent, Jack Mulcock Buckeridge, Alfred Denis Snowden Carter (from Graduate), Francis Charles Case, William John Charnley, Ernest Joseph Redvers Clark, John Stanley Clarke, Francis Nugent Edney, Angus Eggleston, Kenneth Essex-Crosby (from Student), Terence William Frederick Fairbairn (from Student), Gerald Gordon Fowler (from Graduate), Richard William Vessey Grandorge, Keith Percy Green, Austin Griffiths (from Associate), John Humphries (from Graduate), Walter Dickins Hunter (from Graduate), Lionel Cecil James (from Graduate), Hubert Anthony Krasinski, Cecil Beaumont Lewis, Eric Harold Mansfield, Maurice William Martin (from Graduate), James Denning Pearson, Pieter Abraham Peens, Ronald William Smith (from Graduate), Vivian Farrar Smith (from Associate), Ronald Alfred Smithers (from Graduate), Cyril Victor Stanmers, George James Thomson, Charles Keith Turner-Hughes (from Associate), James Carey Wallin (from Graduate), Kenneth Watson (from Associate).

Associates

Stanley George Driver, Thomas Wood Fazakerley, Arthur George Hancocke, Robert Gilbert Byford Hawkins, George Hatton King, Robert Nelson, Frank Parvin, Arthur Leighton Patterson, Harold Stanley Charles Rigby, Donald Albert Rix, Ernest John Roberts, Curt Bernd Alex Schiff (from Companion), George Edward Sibbit, Robert Smyth, Frederick Ernest Sparks, Herbert Charles Taylor, Howard Charles Tinney, John Whelan, Horace Mervyn Whitcombe.

Graduates

John David Arthur, Arthur Edward Mackenzie Barton, William Maurice Brady (from Student), Norman Oliver Brand (from Student), Edwin Arthur Broadhurst, Charles Basil Budd (from Student), Antony George Dixon, Alan Leslie Roy Fletcher, Christopher Huggins (from Student), Albert Ronald Mettam, William Norman Clyde Moore, Cecil James Olaf Moorhouse (from Student), Henry Harrison Morgan, Lesile Joseph Murrin, Dennis Rose, Michael William Salisbury (from Student), Peter John William Tuffs (from Student), Roy Ernest Withey, Ivor Edward Woodroffe (from Student).

Students

Kenneth Hedley Andrews, Richard Francis Beresford, John Chalmers, Peter John Farmer, Gerald Philip Gilbert, John William Howard Grant, Keith Gordon Hodson, Donald Geoffrey Johnson, William John Kenyon, William Stanley Mackie, Peter John Mettam, Thomas Nesbitt, Ronald David Page, Gordon Robert Parker, Anthony Brian Parry, Lionel Rossiter Pool, Hugh Gault Rice, John Scarlett, Louis John Stephenson, Arthur Brian Taylor, Robert John Trees, Arthur Francis Winstanley.

Companions

Edwin Gerard Davidson, Arthur James (from Graduate), Archibald William Alfred Prott Wilson, James Middleton Worthington.

MAY 1949

Associate Fellows

Arthur William Albert Andrews, Frederick Duncan Atkinson, Geoffrey Townsend Dobson (from Graduate), Marc Peter Le Lohe, Henry John Louch.

Associate

Wreford Hilton French.

Graduates

William Norman Bainbridge (from Student), Harold Caplan (from Student), Peter Alex Marks (from Student), Denis Roland Murrin (from Student), George Robert Prime (from Student), John Edward Rapson (from Student).

Students

Manna Lal Agarwala, Clifford John Benjamin, Lyndon Spencer Compton, Laurence Ivan Cook, Jack Samuel Doyle, Jonathan Huntley Wallace Shannon, William Victor Williams.

JUNE 1949

Associate Fellows

Basil Twyman Cheverton, Peter John Cooper, Raymond Edwin Cooper (from Graduate), John Frederick Foss, John Owen Hounsell, Horace Aubrey Jarrett (from Associate), Thomas Hubert Gethin Lewis, Henry Edmund North (from Graduate), Geoffrey John Powter (from Associate), Joseph Rawcliffe, Thomas Dorey Sellwood, Norman William Wakelin.

Associates

John Holt Eaton-Shore, Alexander Sabine Courtenay Lumsden, James Alfred Scott Mills, Frank William Proudlove, Frederick George Beaconsfield Randall, James John Chalmers Reid (from Student), Denis Maule Roberts, Stanley Speight.

Graduates

Michael Henry Beeching, Brian Robert Carter (from Student), Paul Emile Joseph Ghislain Colin, Jal Erach Daboo, Albert Georges Renaud Dechamps (from Student), George Frederick Donno, David Dunlop Ewart (from Student), Ernest Alfred Timby, Paul Anthony Tunbridge.

Student

Eric Cyril Maskell.

JULY 1949

Fellows

Edgar Hilton Atkin (from Associate Fellow), James Valentine Connolly (from Associate Fellow), Percy George Crabbe (from Associate Fellow), Arthur Ernest Hagg, Robert Ernest Hardingham (from Associate Fellow), William Henry Lindsey (from Associate Fellow), John Lloyd, Basil Gervase Markham (from Associate Fellow), David Macleish Smith (from Companion), Richard Walter Walker (from Associate Fellow).

Associate Fellows

Frank Ashton (from Graduate), Frank Camfield Aylesbury (from Associate), Gilbert William Beesley, Graham Brook Bell (from Associate), Edmond Antoine Sylvestre Brun, Paul Cadman (from Graduate), Arthur Capella (from Graduate), Richard Connor, John Edward Curtis (from Graduate), William Deacon, John William Glanfield, Reginald Maurice Gray, Gordon Lander Gunstone (from Student), John Ernest Haines (from Graduate), Manning Harris, Ronald Owen Hender (from Associate), Cyril Francis Holloway (from Associate), Horace Tom Elliott Hone (from Graduate), John Bernard Everett Keeble (from Associate), Richard Norman Kemp (from Graduate), Yehuda Kritchevsky (from Companion), Cyril William Lawrence, Dennis Lean, Anthony Brian Davies Leigh (from Graduate), Daniel Llewellyn, Sidney Walter Douglas Lockwood, Ian Alfred Thomas Lumsden (from Graduate), Philip Raymond Martin, John Bush Matthews, Edward Frank Mitchell (from Graduate), Kenneth Harold Oosterlaak, Earl Pine Osborn, Joseph Rimmington, David Sadler (from Graduate), Peter Edward Saunders (from Graduate), Max Olivey Scott, Charles Frederick Smart, Bernard Hugh Stanley (from Graduate), Robert Henry Stevens (from Graduate), Ernest Knightley Wellsted, Robert Michael Wingate (from Student), Herbert Wager Winterbottom (from Graduate), John Leonard Wood (from Graduate), George Young.

Associates

Arthur Frederick Childs, William Henry Gray Wishart Finlay, Leslie Griffiths, George Aaron Hargrave, Frederick John William Harwood (from Student), Donald William Kemp (from Student), Alfred Walter Liquorish (ex-Student), Charles Geoffrey Millier (from Student), Robert Vernon Moxey, Thomas Victor Orgill, Kenneth McLean Park (from Student), Ronald Alfred Pearson, William Edward Plummer, Reginald William Macer Sennitt, Oswald Thomas Shorthouse, Arthur Edward Slocombe, Herbert Charles Taylor, Peter Ignatius Taylor, Andrew Waugh, Albert Cyril Wilson.

Graduates

Sydney Edward Adams, Frederic Bedrich Adler, David George Baker (from Student), M. S. Balasubramanian (from Student), Rowland John Barnard, Derek George Brown (from Student), Derek Stuart Capps, Leslie Maurice Carlile (from Student), William Harry Casley, Arthur Cecil Ronald Collins, William George Corbett (from Student), Thomas Norman Corkill (from Student), Peter Davenport (from Student), Joan Lidster Davis (from Student), Edward R. Geargeoura, Roy Michael Gibson, Alan Geoffrey Rolfe Gilbert, John Robert Hair, Thomas Leonard Hall, Alan Roy Hammond (from Student), Kenneth Thomas Jackson, Gordon Ernest Jervis, Jacek Kundycki, K. Kwiatkowski, Alkis N. Lagopoulos, Peter Richard

Lodge, Colin Sidney Ritchie Marshall, Alec Measures (from Student), Hans Hermann Neustadt, Geoffrey Herbert Nixon, Bryan Rex Noton (from Student), James George Alexander Paterson (from Student), John Charles Henry Peaker, Jack Phillips, Alan Powell (from Student), William John Rainbird, Alan Middleton Rawlings, Josef Rosenthal, Robert Loosemore Scotland, John Anthony Scott (from Companion), Arnold John Sobey, Cyril William Soley, Keith Donald Thomson (from Student), Donald Francis Vowles.

Students

Gerard Edmund David Bonham-Carter, Reginald Guy Boor, Francis Henry Borlace, Trevor Gerald Evans, Victor Nigel Ferriman, Victor Albert Hindley, Daniel John Holding, John Frederick Jones, Raymond Charles McNamara, Thomas Timothy Mehigan, John Desmond Penrose, Robert Victor Read, John Albert Ross, Robert John Saker, Ian Thompson Smyth, Richard James Starling.

Companion

Trevor Sratton Braybrooke (from Graduate).

AUGUST 1949

Fellows

Arthur Lorne James (from Associate Fellow), Elizabeth Muriel Gregory McGill (from Associate Fellow), John Knudsen Northrop.

Associate Fellows

William Liddiard Amer, Kenneth Charles Ball (from Graduate), Howard John Bell-Walker, Cornelis Johannes Marinus Benard, Frederick Thomas Bevan (from Associate), Derek LeRoy Bird (from Graduate), Arnold Amherst Buchanan, William Augustus Cheesewright, Stanley William Chisman (from Graduate), Peter Rowland Crewe, Ivor Macaulay Davidson (from Stu[illegible]old Davies, Herbert David Denchfield (from Student), Eric Downham, [illegible]John Earnshaw, Albert George Mark Elliott (from Graduate), Roy Fairclough, Lorenzo Pedro Fontana, Howard Stanley Fowler (from Graduate), Kathleen Margaret Fowler, Denys Thomas Glover, Gustaf Gudmundson (from Associate), Ronald Frank Wortley Guest, John Maxwell Hands (from Graduate), John Jack, Vincent Peter Kelly, Derek Joseph Lambert (from Graduate), John Albert Lawford, Herbert John Sherwood Leslie, Marian Josef Kazimierz Lesniak, Kelvin Oliver Lockyear (from Graduate), William James Johnstone Macdonald (from Graduate), John Irwin McKillop, George Maurice Martin Magill (from Graduate), Maurice George Marsh (from Graduate), Rodney Melling (ex-Student), Wilfred Ernest Martin Miller (from Associate), Charles Reginald Milne (from Graduate), Pierre Moraux, Ian Thomas Alexander Murchie (from Graduate), Beryl Catherine Myatt (from Student), Keith Robert Obee (from Graduate), Frank Cyril Petts (from Associate), Lewis Raymond Phillips (from Graduate), Peter Scott Pickles, Robert Hillson Poynton, Eric Francis Price, Joseph McAdam Rainey (from Graduate), Gwendolen Marjorie Roper, Duncan Saunders (from Graduate), Edward Simpson (from Associate), Robert Skinner (from Graduate), Peter Egbert Arthur Stevenson (from Student), Walter Henry Soutar (ex-Student), Leonard Livingstone Summers, Dennis Ian Thompson (ex-Student), Jack Percival Thompson (from Associate), David Herbert Whaley (from Graduate).

Associates

Herbert Denis Burke, Richard Carrall, Percy Edmund Walter Chorley, Wilfred Henry James Dibbens, Jack Drew, Irene Joy Ferguson, Battista Louis Gagliardi (from Companion), Victor Arthur Gittins, Roy Holland, Kenrick Jones, John Alexander Kent, Arthur Nigel Kitching, Fredrick Godson Ling, Harold Luskin, Laurence Malec, Harold Maurice Newton, William Hamilton Oliver, Gartrell Richard Ian Parker, Ernest Lane Pearson, George Raymond Roscoe, Richard Brian Stratton, John Syrad (from Student), Leslie Taylor, Thomas Russell Thomson, Ian Tongue (from Student), John William Thomas Wheeler, Thomas Alfred Yates.

Graduates

Alan Leonard Baker (from Student), Rollin Hamilton Bates (from Student), Connell Frederick Bee (from Student), Raymond Arthur Birch, Fred Bradshaw, Ronald Hugh Campbell, John Frederick Cannell (from Student), Kenneth John Coleman (from Student), Leslie Cedric Collins, James Percival Crossley, John Harold Drake (from Student), David Swales Forsyth, John Alan Fuller, Alan Stanley Gander, Reginald Bertram Glanville-Wood (from Student), Bernard Irvin Grant, Stanley Gray, Donald Griffiths, Kenneth Ronald Guy (from Student), James Charles Hateley, Patrick Alan Hatswell, John Arthur Godfrey Holmes, William Donald Horsfield (from Student), George John Houghton (from Student), Albert Hayden George Jeffery, Rajendra Nath Kashyap, Eric Dorian King (from Student), Ernest Fintan Lawlor (from Student), Leslie Walter Lawrence (from Student), Philip George Lockington (from Student), John McCulloch (ex-Student), Archibald Bathgate McKenzie (from Student), David Albert Needs, James Antony Rowland (from Student), Kenneth Osborn Scott, Ronald George Smith, John Trevor Stamper (from Student), Trevor Edwin Arthur Stevenson (from Student), Peter Latham Sutcliffe (from Student), Robert Lindsay Whiteley (from Student).

Students

San Hla Aung, Aland Leslie Hall, Donald Peter Charles Kemp, Kenneth Cuthbert Kinghorn, Alan Knight, Aubrey Benjamin Knight, William Henry Napthine, Krishnan Aditya Varman Pandalai, Clerwyn David Roberts, Rakhal Das Saha, Richard George Spencer.

Companions

John Scholes Aked, Frank Henry Bellis, C. R. Rajagopal.

SEPTEMBER 1949

Fellow

Ivan Howard Driggs (from Associate Fellow).

Associate Fellows

Thomas William Aynsley (from Student), John Goldfinch, Thomas William Harper, Edwin Lloyd, Maxwell Norman Oxford (from Associate), Herbert Stanley Perry, John Gilbert Russell (from Associate), George Charles Wainwright, Raymond Wilks (from Graduate), Eric Gillard Wilson (from Graduate).

Associates

Carl Agostini, Edward C. Daw, Eric John Dickie, Gordon Stanley Gee (from Graduate), Louis Charles Giles, David Leslie Russell Halliday, Norman Arthur Webb Kitto, Frederick Norville, James Matthew Thom Ormerod.

Graduates

Tom Bromlet Gregory, Ronald Hooper (from Student), Heinrich Rudiger Ilgen, Derek Pym, Thomas Alfred Webb, Cyril Thomas Wheatcroft, Kenneth William Wreghitt.

Students

John Herbert Bibo, David Thomas Miller, Clifford Henry Talbot.

OCTOBER 1949

Associate Fellows

Arthur Neville Barber, George Bruce Bolt, Bevis Portuis Chevry de Bray, Gordon Ronald Douglas Calder (from Graduate), Rowland Bennet Coles, William Harold Dainty (from Graduate), Alfred John Douch (from Associate), George William Ellis (from Graduate), Lionel Richard Stanford Freestone, Peter John

Fullam (from Graduate), Donald John Harper (from Student), John Oliver Hitchcock, Richard John Harris Isaacs, Francis Douglas Claringbould Jeffery, Kenneth Riley Firth Kenworthy (from Associate), Edward Albert Langridge, George Herbert Lee, Sidney Lipman (from Graduate), Philip Nash, Norman Francis Newbery, John Stuart Newman, Alfred Salem Niles, Frederick James Pacey, Peter William Parish, Richard Wigmore Foster Pegg, Cyril John Simmonds, Horace Smith (from Associate), Fredrick Alan Spurr (from Graduate), Henry Ralph Stratford, Albert Mark Taylor, Donald Sydney Thomas (from Graduate), Sidney Tyes (from Graduate), Alan Vines, Charles Hugh Elsey Warren, Sidney Charles Wybrow (from Associate).

Associates

Arthur Leslie Ashby, Leslie Francis Graves Badham (from Companion), Alfred Charles Gordon Baldwin, M. Bimbet, William Robert Bitcheno, Fred Bradford, Cyril Edwin Chapman, Kenneth Rawson Collins, James Gordon Holt Cooper, John Arthur Danes, Peter John Detmold (from Student), John Francis Flavin, Eric Garner, William James Martel Gatehouse, James Crawford Halley, William Whilton Harvey, John Francis Higgins, Norman Parry Hughes, Percy Johnson, John Kissack, Graham John Macrae (from Student), William Robert Joseph Marriott, Noel Butcher Miller, David William Morgan, Thomas Ronald Newton, David Eric Proudlove, S. Ramakrishna, Richard Henry Reynolds (from Companion), Ian Alexander Robertson, Albert Roman, Kesharikumar D. Shah, Ronald Arthur Sutherland, Tin Maung Than (from Student), Ernest Frederick Charles Worthy, Sami Zaki.

Graduates

Walter James William Arnell, John Atkinson, Demond Barnsley, Thomas William Henry Brown, John Ernest Carpenter, Alric Ronald Cawthorne (from Student), John Chalmers (from Student), James Clarkson, Anthony Richard Ward Denison (from Student), Brian Ronald Diplock, John Finnigan (from Student), Terence Edmund Ford (from Student), Ulric Keith Gerry (from Student), Charles Forrest Graham (from Student), Ernest Noel Grantham, Prem Chandra Gupta, John Michael Hardman, Derek Vance Hilborne (from Student), William Henry Johnson, Neville George King, William Stanley Mackie (from Student), John Geoffrey Male (from Student), Sydney Arnold Matthews, Eric Milburn (from Student), Peter de Buriatte Philpot, Frederick William Pillinger (from Student), John Reginald Pope (from Student), Grahame Charles Quigg, Kenneth George Rendle, Wallis Parkinson Stack (from Student), Dennis Clifford Stevenson, Peter Duncan Stewart (from Student), Jonathan Swainson (from Student), George Ernest André Thomann, John Thompson (from Student), Peter Murray Twiss, James Herbert William Wheatley (from Student), Joseph Alexander Williams, Leslie Wookey (from Student).

Students

Kenneth Walter Batten, John Bright, Roland Dennett, Michael John Evans, Dennis James Farmer, Ramsden Fisher, Malcolm Curtis Hall, Maung Tun-Maung, Robert Martin Oldershaw, Peter Sidney Richardson, Cecilia Mary Solvejg Slattery, John Harry Smith.

NOVEMBER 1949

Associate Fellows

James Alexander Gwilym Diack (from Graduate), Philip Gerard Duff, Ronald Ferrari (from Graduate), Walter Edmund Hogsflesh (from Associate), Richard Joseph Ifield (from Associate), Bennett Isherwood (from Student), K. Ramachandran, Donald Selvey, Sidney William Henry Wood (from Graduate).

Associates

Archibald Currie Beazer, Alan Edgar Bristow, Fred Brooks, John Doherty, Hugh Kelvin Ford, Michael Eveness Haldane Grant (from Student), Llewellyn Ernest Hartridge, Herbert David Laidlaw, Maitland Robert Roper, John Vivian Stanbury.

Graduates

Robert Malcolm Allan (from Student), Roy Gregory Barnden (from Student), Leonard Stanley Davey, Kenneth James Iddon (from Student), Philip John Mitchelmore, Tadeusz Pasternak, Bernard John Preston (from Student), David Hunter Thomson, Vincent David Trimm.

Students

Stuart Grant Harris, Roy Gordon Lewer, John David Roberts, John Shields.

DECEMBER 1949

Fellow

Jules Louis Albert Jarry (from Associate Fellow).

Associate Fellows

William Francis Andrews, William Baillie, Owen Richard Ballard (from Graduate), Roy Desmond Boot (from Graduate), Charles Edward Fraser Brown, Alan Colin Campbell Orde, Donald Clayson (from Associate), Harold Murray Ellins (from Graduate), Roger Quentin Eden Eden (from Graduate), Ernest Malcolm Elliott, Edward William Fidler (from Companion), Jack Ford (from Graduate), Robert Frederick Freitag, Thomas William Funston, Raymond Dennis Green, Stanley Peter Hawes (from Graduate), William Geoffrey Heath (from Graduate), Jonathan Huddart, John Alexander Jefferson-Loveday (from Graduate), Francis Henry Keast (from Graduate), Wilfred James Kelly (ex-Student), Marcel Jules Odilon Lobelle, Norman Wilkinson McCue, Rolf Frederick Marshall (from Student), Eric John Martin (from Associate), Bernard Alexander Masters, Albert Ronald Mettam (from Graduate), Dennis James Moore, Michael John Mott (from Graduate), Kenneth William Norris (from Graduate), Ivan James de la Plain, Leonard Redmayne, Charles Arthur Robinson (from Associate), Arthur James Edward Thornton, Morton Eric Turner, David William Ricketts Vincent, Robert John Edward Walker, Duncan Fairlie Wilson (from Associate), Peter Frank Witherden (from Graduate).

Associates

Frederick Oliver Barrett, Hazel Florence Brookes (from Student), Thomas Wight Campbell, Dennis Stratton Carton, Gaganendra Chandra Datta (ex-Associate), Peter Mainwaring Dunstan, Douglas Somerville Fuller (from Student), Owen Desmond Arthur Charles Furlong (from Student), Eric William Goode, Tore Ragnar Gullstrand, Peter Myles Irwin, Leslie Edwin King, James McAvoy, Derek Moncrieffe Mackay (from Student), Denis Patrick McMahon, Peter Lewis Martin, Dennis Nolan-Neylan, Robert Mervyn Tricker Ollis, Ernest Belford Parsons, John Davidson Ratchford, John Hardman Rawcliffe, Vincent Mervyn Ambler Richardson, Satyendra Kumar Roy, William Basil Kenyon Searle, Wilfred Vincent Smythe, Adrian Frederick Rex Stedman (from Student), Ian Radnor Stephens, John Francis Victor Veillard, Alexander Millar Wylie.

Graduates

Sheikh Mukarram Ali, Reginald Albert Lloyd Arkell (from Student), Denis Walter Barnes, Norman Atherstone Hilton Barraud, Anthony James Barrett (from Student), Eric Brelsford, Bernard Caiger (from Student), Ronald Sidney Capewell, Jacob Alexander Bruce Cartmel (from Student), John Bradley Chaplin (from Student), Dennis Collins, Thomas Patrick Doherty, Kenneth Edgerton (from

Student), Alan Howard Farrow, Brian William Firth (from Student), John Walter Flower, Arthur Sydney Forster, John Cecil Geering, Norman Michael Gemson (from Student), Roger Henry Ernest Goodman, Bernard Stephen Hanson (from Student), William John Harbottle (from Student), Cecil John Hart, Richard John Herbert (from Student), Paul Alexander Hilton (from Student), William Rogers Hoskin, Cyril Gwynne Hughes (from Student), Michael Stewart Igglesden (from Student), Gautam Khosla, Simon Kugler (from Student), Arthur George Kurn, Ernest Theodore Labett, Richard Alvin Mathias Lewis (from Student), Jack Walter Lloyd, George Maitland (from Student), Eric Cyril Maskell (from Student), John Edward Nethaway (from Student), Peter Maurice William Noel (from Student), William Michael Geoffrey Owen, Geoffrey Keith Charles Pardoe (from Student), Jagdish Chandra Pathak, Clive Redmayne, John Roy Richardson (from Student), Rodney George Rose (from Student), Jeffrey Scoresby, Michael Edmund Lock Spanyol, Gordon Edwin Staples (from Student), John Herbert Stephens (from Student), Robert Walter Wilson Tennant, Philip Rupert Thompson, Alan Sydney Thurley (from Student), Edward Trim, Kenneth John Turner, Joseph Waters (from Student), Jack Victor Athelstane Welbourn, Albert Edward White, James Lanham Wildhaber (from Student), Alan Wilding, John Malcolm Williams (from Student), Sinclair Murdoch Wilson, Robert Francis Henry Woodberry (from Student), William Butler Wright, Desmond John Yabsley.

Students

Bernard George Ambrose, Peter Alfred Thomas Christopher, Robert Edward Finch, Alexander Henry Fraser-Mitchell, Ramond Lionel Gamlin, Lawrence Frank Gillard, George Kenneth Frank Green, Ronald Charles Harris, Volrath Holmboe, Dalbir Kumar Kapur, Bryan McHugh, Denis John Powell, Peter Henry Raymond, Gerard Raphael Soffe, John Robert Williams.

Companion

John Oliver Montanaro.

ASSOCIATE FELLOWSHIP EXAMINATIONS

The new Associate Fellowship Examination Syllabus came into force on 1st January 1949. Part I of the examination became operative on that date but papers continued to be set in the old syllabus until the end of 1949.

The following candidates were successful in the Examination held in December 1948:—

HOME

Adler, F. B., Theory of Internal Combustion Engines, Design (Aero Engines); Agrawal, P. C., Pure Mathematics; Ali, M., Theory of Internal Combustion Engines; Ansell, J. J., Theory of Machines; Atkinson, J., Pure Mathematics, Theory of Internal Combustion Engines (1st place), Aircraft Materials.

Barnard, R. J., Air Transport; Barraud, N. A. H., Pure Mathematics; Beanland, D. F., Applied Mathematics, Theory of Internal Combustion Engines, Design (Aero Engines); Bigg, B. M. (Miss), Pure Mathematics, Strength of Aeronautical Materials and Structures, Theory of Machines; Brown, T. W. H., Applied Mathematics, Theory of Internal Combustion Engines, Theory of Machines; Burke, D. M., Applied Mathematics.

Capewell, R. S., Applied Mathematics, Theory of Machines; Carrivick, W. P., Pure Mathematics; Casley, W. H., Applied Mathematics, Theory of Internal Combustion Engines, Theory of Machines; Chifrine, S. B. S., Aircraft Materials.

Davies, I. J., Pure Mathematics; Deacon, S. M. (Miss), Pure Mathematics; Dean, J. S., Applied Mathematics, Theory of Machines; Denchfield, H. D., Strength of Aeronautical Materials and Structures, Aircraft Materials; Dixon, E. D., Theory of Machines; Dowell, K. J., Aircraft Instruments; Drayton, F. A., Theory of Internal Combustion Engines.

Eccles, D., Strength of Aeronautical Materials and Structures; Edwards, P. A., Strength of Aeronautical Materials and Structures.

Ferguson, J. F. (Belfast), Theory of Internal Combustion Engines, Design (Aero Engines); Forbes, I. A., Theory of Machines; Fuller, J. A., Design (Aero Engines).

Gardner, J. F., Aircraft Materials; Geargeoura, E., Theory of Internal Combustion Engines; Geering, J. C., Applied Mathematics; Glew, C. A., Pure Mathematics; Godfrey, D. W. H., Pure Mathematics, Theory of Machines, Design (Aircraft); Griffiths, S. Applied Mathematics, Theory of Internal Combustion Engines, Design (Aero Engines).

Hagan, W. E., Air Transport; Hainsselin, T. M., Pure Mathematics; Harbottle, W. J., Applied Mathematics; Harding, B. A., Strength of Aeronautical Materials and Structures; Hart, C. J., Theory of Internal Combustion Engines; Hayward, D. W., Strength of Aeronautical Materials and Structures; Hilton, P. A., Pure Mathematics; Hoskin, W. R., Applied Mathematics, Theory of Internal Combustion Engines; Hurrell, R. V., Pure Mathematics; Theory of Machines.

Jack, J., Design (Aero Engines); Jacob, D. L., Applied Mathematics; James, J. N., Theory of Internal Combustion Engines, Theory of Machines.

Kashyap, R. N., Pure Mathematics, Strength of Aeronautical Materials and Structures, Theory of Machines; Keeble, J. B. E., Aircraft Materials (1st place); Khote, H. V., Pure Mathematics, Design (Aircraft); Kirkby, J. N., Pure Mathematics; Knight, A., Pure Mathematics, Theory of Machines, Design (Aircraft) (1st place); Kundycki, J., Applied Mathematics, Theory of Internal Combustion Engines, Theory of Machines; Kurn, A. G., Applied Mathematics, Theory of Machines; Kwiatkowski, K., Applied Mathematics, Theory of Internal Combustion Engines, Theory of Machines.

Lagopoulos, A. N., Applied Mathematics, Theory of Internal Combustion Engines, Theory of Machines; Lewis, W. W. (Belfast), Applied Mathematics, Design (Aircraft); Lie, J., Pure Mathematics.

McLaughlin, P., Theory of Machines; Male, J. G., Strength of Aeronautical Materials and Structures; Malecki, T., Theory of Machines; Manners, H. J. F., Applied Mathematics; Marshall, C. S. R., Applied Mathematics, Theory of Internal Combustion Engines, Theory of Machines; Martin, E. J., Applied Mathematics, Air Transport (1st place); Martindale, J. P. A., Theory of Internal Combustion Engines, Wireless Telegraphy and Telephony and their Application to Aeronautics; Milns, P., Pure Mathematics, Strength of Aeronautical Materials and Structures, Aerodynamics; Miller, R. D. W., Pure Mathematics; Molony, A. J. B., Applied Mathematics; Montanero, J. O., Applied Mathematics, Theory of Internal Combustion Engines; Morley, F. J., Pure Mathematics, Strength of Aeronautical Materials and Structures (1st place), Design (Aircraft); Mort, J. L., Applied Mathematics; Mozolewski, M., Theory of Machines.

Neustadt, H. H., Applied Mathematics, Theory of Internal Combustion Engines, Design (Aero Engines); Nicholas, R. G., Applied Mathematics.

Pasternak, T., Theory of Internal Combustion Engines; Patchett, B. W., Applied Mathematics; Pathak, J. C., Theory of Internal Combustion Engines; Peddle, H. L., Applied Mathematics; Petts, F. C., Theory of Internal Combustion Engines, Meteorology and its Application to Aeronautics; Phillips, J., Applied Mathematics, Theory of Internal Combustion Engines, Theory of Machines; Philpot, P. R., Pure Mathematics, Theory of Machines; Pinchin, F. D. J., Aircraft Materials; Pratt, J., Applied Mathematics.

Raynes, J. L., Theory of Internal Combustion Engines; Reynolds, B., Pure Mathematics, Aircraft Materials; Ronson, G. L., Design (Aero Engines) (1st place); Rosenthal, J., Theory of Internal Combustion Engines, Design (Aero Engines); Ross, P. T., Pure Mathematics; Rouffignac De, B. K., Applied Mathematics.

Scallon, D. P. L., Pure Mathematics; Senathiraja, P. W., Applied Mathematics; Sharp, J. R., Applied Mathematics, Theory of Internal Combustion Engines, Theory of Machines (1st place); Sice, L. J. A., Theory of Machines; Smith, A. W. J., Theory of Internal Combustion Engines; Smith, S. H. P., Theory of Internal Combustion

Engines; Spanyol, M. E. L., Pure Mathematics, Strength of Aeronautical Materials and Structures; Spong, J. M., Theory of Machines; Starling, R. J., Pure Mathematics (1st place), Strength of Aeronautical Materials and Structures, Theory of Machines; Stevenson, P. E. A., Theory of Machines; Swingler, J. A. Design (Aircraft).

Thomas, D. T., Applied Mathematics, Theory of Internal Combustion Engines, Theory of Machines; Thompson, A. M., Aerodynamics; Toner, E., Theory of Machines, Aircraft Materials; Thurston, J. M., Applied Mathematics, Theory of Machines.

Uydens, A., Aerodynamics.

Wakeford, J. G., Pure Mathematics; Bell-Walker, J., Design (Aircraft); Walker, R. J. E., Pure Mathematics; Walley, G. D., Strength of Aeronautical Materials and Structures; Warhaftig, W., Theory of Internal Combustion Engines, Theory of Machines; Watkins, K. W., Strength of Aeronautical Materials and Structures; Willcocks, H. J., Applied Mathematics, Theory of Machines, Aircraft Instruments Theory and Design (1st place); Williams, J. M., Pure Mathematics, Theory of Machines; Williams, R. J., Aircraft Materials; Wilson, D. F., Theory of Internal Combustion Engines; Winyard, A., Pure Mathematics; Woodwell, N., Theory of Internal Combustion Engines, Design (Aero Engines); Woolf, P. A., Aircraft Instruments—Theory and Design.

Yusuf, M. A., Theory of Internal Combustion Engines.

ABROAD

Balasubramanian, M. S. (Bombay), Aircraft Materials; Bhardwaj, D. N. (Bombay), Air Transport. Cooke, A. (Montreal), Theory of Internal Combustion Engines. Davison, J. W. (Wellington), Theory of Machines. Edwards, J. F. (F/Sgt.) (B.A.O.R.), Theory of Internal Combustion Engines, Theory of Machines. Gassin, P. C. (Calcutta), Theory of Internal Combustion Engines. Ilgen, H. R. (Amsterdam), Applied Mathematics, Strength of Aeronautical Materials and Structures, Design (Aircraft); Iskander, R. (Egypt), Applied Mathematics, Strength of Aeronautical Materials and Structures. Kumar, V. (F/Lt.) (Kanpur, India), Applied Mathematics. Law, E. H. (F/Sgt.) (Auckland), Applied Mathematics. Rao, H. A. R. (Bangalore), Aircraft Materials; Rao, N. S. Negasubba (Madras), Pure Mathematics; Roper, M. R. (Wellington), Strength of Aeronautical Materials and Structures. Stern, L. (Melbourne), Applied Mathematics. Townend, F. L. (Nav. II) (Koggala, Ceylon), Design (Aero Engines); Trinder, T. V. (Pretoria), Theory of Internal Combustion Engines. Vaidyanathan, J. (Madras), Navigation and its Application to Aeronautics.

The following candidates were successful in the Associate Fellowship Examinations held in May 1949:—

M. Ali, Theory of Machines.

N. W. Barford, Aerodynamics; C. R. P. Barlow, Theory of Machines, Pure Mathematics; N. A. H. Barraud, Strength of Aeronautical Materials and Structures; N. W. M. Beatts, Strength of Aeronautical Materials and Structures, Pure Mathematics; G. T. Biermann, Design (Aircraft); R. A. Blythe, Pure Mathematics; E. L. Bond, Strength of Aeronautical Materials and Structures; H. C. Bowell, Theory of Internal Combustion Engines; C. R. Broughton, Design (Aircraft), Theory of Machines; W. Burley, Air Transport, Pure Mathematics.

R. S. Capewell, Theory of Internal Combustion Engines; J. B. P. Causley, Design (Aircraft), Pure Mathematics; H. K. Cartwright, Theory of Internal Combustion Engines; W. P. Carrivick, Pure Mathematics; A. D. Chapman, Design (Aircraft), Applied Mathematics; W. E. Coe, Pure Mathematics; A. L. Cole, Theory of Internal Combustion Engines; P. H. Cook, Pure Mathematics; E. N. Crabbe, Design (Aircraft); G. St. Q. Crocket, Aerodynamics, Pure Mathematics.

J. S. Dean, Aerodynamics; G. P. Dollimore, Strength of Aeronautical Materials and Structures; P. C. Donovan, Theory of Machines, Pure Mathematics.

P. J. Farmer, Pure Mathematics.

J. C. Geering, Strength of Aeronautical Materials and Structures, Aerodynamics; N. Ghose, Theory of Machines (1st place), Theory of Internal Combustion Engines; F. S. Glew, Strength of Aeronautical Materials and Structures; C. A. Glew, Theory of Machines, Theory of Internal Combustion engines; T. W. Godden, Air Transport (1st place); J. H. Gordon, Applied Mathematics.

W. E. Hagan, Applied Mathematics; J. W. Haggas, Strength of Aeronautical Materials and Structures, Pure Mathematics, Applied Mathematics; T. M. Hainsselin, Strength of Aeronautical Materials and Structures; L. G. Hall, Pure Mathematics; J. D. Hallett, Strength of Aeronautical Materials and Structures, Pure Mathematics; W. J. Harbottle, Strength of Aeronautical Materials and Structures, Theory of Machines; J. P. Harris (Miss), Aerodynamics; C. J. Hart, Applied Mathematics; P. A. Hilton, Strength of Aeronautical Materials and Structures; J. H. Hurford, Pure Mathematics; R. V. Hurrell, Aircraft Instruments—Theory and Design.

F. Jackson, Pure Mathematics.

D. K. Kapur, Applied Mathematics; R. N. Kashyap, Aerodynamics; J. N. Kirkby, Strength of Aeronautical Materials and Structures; M. Kishor, Applied Mathematics; A. G. Kurn, Theory of Internal Combustion Engines.

G. W. Little, Strength of Aeronautical Materials and Structures.

K. J. Mackenzie, Pure Mathematics; J. G. Male, Aerodynamics; H. J. F. Manners, Theory of Machines; J. C. Martin, Strength of Aeronautical Materials and Structures; E. J. Martin, Theory of Internal Combustion Engines; J. Mawer, Pure Mathematics; R. D. W. Miller, Strength of Aeronautical Materials and Structures, Theory of Machines, Aerodynamics; J. O. Montanaro, Theory of Machines; J. L. Mort, Design (Aircraft); A. K. Mubarak, Pure Mathematics; K. K. Mukerjee, Pure Mathematics.

D. Nayler, Pure Mathematics (1st place); J. S. Nayler, Strength of Aeronautical Materials and Structures; J. M. Nelmes (Miss), Theory of Machines, Pure Mathematics; N. N. Nicholls, Pure Mathematics.

J. C. Pathak, Meteorology and its Application to Aeronautics; J. W. Paulsen, Pure Mathematics; L. R. Pool, Applied Mathematics (1st place); A. T. Pugh, Strength of Aeronautical Materials and Structures.

B. E. Rayner, Strength of Aeronautical Materials and Structures, Pure Mathematics; B. Reynolds, Strength of Aeronautical Materials and Structures; W. W. Ringland, Design (Aero Engines), Theory of Internal Combustion Engines, Applied Mathematics; P. T. Ross, Strength of Aeronautical Materials and Structures; H. M. Roy, Pure Mathematics.

M. Saeed, Pure Mathematics; D. Shellard, Pure Mathematics; E. Slap, Theory of Machines, Theory of Internal Combustion Engines; A. W. J. Smith, Design (Aero Engines); M. F. Smith, Strength of Aeronautical Materials and Structures, Pure Mathematics; A. E. Southgate, Theory of Internal Combustion Engines, Aerodynamics, Pure Mathematics; J. M. Spong, Applied Mathematics; R. G. Spencer, Design (Aircraft), Theory of Machines, Pure Mathematics; G. C. Sugden, Aerodynamics, Applied Mathematics; J. A. Swingler, Theory of Machines.

C. R. Taylor, Pure Mathematics; E. Toner, Applied Mathematics; P. E. Tweed, Strength of Aeronautical Materials and Structures.

A. Uydens, Strength of Aeronautical Materials and Structures.

H. Vogel, Pure Mathematics.

J. G. Wakeford, Design (Aircraft); P. E. Walters, Pure Mathematics; K. W. Watkins, Pure Mathematics; K. R. Warren, Air Transport; J. M. Williams, Strength of Aeronautical Materials and Structures; P. J. Wingham, Theory of Machines, Aerodynamics (1st place), Pure Mathematics; P. A. Woolf, Pure Mathematics; W. B. Wright, Theory of Internal Combustion Engines; J. Wyatt, Applied Mathematics.

M. A. Yusef, Strength of Aeronautical Materials and Structures.

ABROAD

C. G. Andrews (Wellington, New Zealand), Strength of Aeronautical Materials and Structures; W. J. Bouma (Amsterdam, Holland), Air Transport; V. R. Bunyard, (Port Elizabeth, South Africa), Strength of Aeronautical Materials and Structures, Aircraft Materials; J. W. Davison (Auckland, New Zealand), Strength of Aeronautical Materials and Structures, Aircraft Materials; S. Emer (Calgary, Canada), Pure Mathematics; R. S. Gopalachar (Bangalore, India), Strength of Aeronautical Materials and Structures; C. J. Horne (Calgary, Canada), Pure Mathematics, Strength of Aeronautical Materials and Structures; W. G. Johnson (Malaya), Applied Mathematics; S. V. Karandika (Bombay, India), Pure Mathematics, Aerodynamics; N. Krishnappa (Bangalore, India), Strength of Aeronautical Materials and Structures; C. L. Matthews (Calgary, Canada), Pure Mathematics, Strength of Aeronautical Materials and Structures, Aircraft Materials; F. A. A. Palmer (H.M.S. *Falcon*, Malta), Theory of Internal Combustion Engines; H. A. R. Rao (Bangalore, India), Theory of Internal Combustion Engines; M. R. Roper (Wellington, New Zealand), Aircraft Materials (1st place); H. A. Schilling (Calgary, Canada), Pure Mathematics; K. R. Simpson (Calgary, Canada), Aircraft Materials; K. S. Suryanarayanan (Bangalore, India), Strength of Aeronautical Materials and Structures (1st place), Design (Aircraft); L. G. Thomas (Calgary, Canada), Pure Mathematics, Strength of Aeronautical Materials and Structures.

NEW SYLLABUS ENTRIES

B. R. A. Burns, Pure Mathematics; Properties of Matter, Heat, Light and Sound; Aerodynamics I; Strength of Aircraft Materials and Theory of Structures I.

B. M. Laven, Pure Mathematics; Aerodynamics I; Strength of Aircraft Materials and Theory of Structures I.

WILBUR WRIGHT LECTURE

The Thirty-Seventh Wilbur Wright Memorial Lecture was delivered on Thursday, 28th April 1949 by Dr. Hugh Dryden, F.R.Ae.S., Director of Aeronautical Research to the National Advisory Committee of Aeronautics, on " The Aeronautical Research Scene—Goals, Methods and Accomplishments." The complete report was published in the July 1949 JOURNAL.

LOUIS BLERIOT LECTURE

The Second Louis Bleriot Lecture was delivered in London on Thursday, 10th February 1949 by M. Jean Brocard and M. François Hussenot on French Practical Aerodynamic Methods. A complete report was published in the June 1949 JOURNAL.

The Louis Bleriot Lecture is given alternately in Paris and London under the auspices of the Association Française des Ingènieurs et Techniciens de l'Aéronautique and the Royal Aeronautical Society, respectively.

BRITISH COMMONWEALTH AND EMPIRE LECTURE

The Fifth British Commonwealth and Empire Lecture was delivered on Thursday, 15th September 1949 by Mr. E. H. Atkin, F.R.Ae.S., Chief Designer, Airframe Division, A. V. Roe Canada Ltd., on Inter-City Transport Development on the Commonwealth Routes. The complete report was published in the November 1949 JOURNAL.

LECTURES 1949

(Unless otherwise stated all the Society's main lectures were held in the Lecture Hall of the Institution of Civil Engineers by kind permission of the Council of the Institution)

During 1949 the Council decided to extend the Society's Lecture Programme to include subjects of specialised interest ranging over the many different branches of science and engineering. To interest the specialist and to assist the junior members

770577

of the Society a series of special lectures, called Section Lectures, were held in the Library at 4 Hamilton Place during the Autumn Session.

The Section Lectures, which were most successful, were similar in form to University Lectures and were followed by a general discussion.

MAIN LECTURES

13th January—The Auto Pilot, by F. W. Meredith, B.A., F.R.Ae.S.

27th January—Radar as an Aid to the Study of the Atmosphere, by Dr. F. E. Jones, M.B.E., B.Sc., A.M.I.E.E.

10th February—THE SECOND LOUIS BLERIOT LECTURE: French Practical Aerodynamic Methods, by Monsieur Brocard and Monsieur Hussenot.

17th February—Planned Servicing in the Royal Air Force, by Squadron Leader E. A. Harrop, O.B.E., A.F.R.Ae.S.

24th February—Flutter and Stability, by Professor W. J. Duncan, B.Sc., F.R.Ae.S., M.I.Mech.E., F.R.S.

5th March—FULL DAY DISCUSSION ON AIR SAFETY.

Morning Session

The Theoretical Aspects of Airworthiness and Safety, by J. D. North, F.R.Ae.S.

The Physiological Aspects of Safety, by Dr. K. G. Bergin, M.A., M.D., A.F.R.Ae.S.

Afternoon Session

Safety from the Pilot's View Point, by Captain J. W. G. James, O.B.E.

Operational Research into Air Traffic Control, by Dr. G. E. Bell, M.Sc.

Evening Session

General Discussion and summing-up by the Lecturers and the Chairman.

17th March—The Design of Propellers, by G. C. I. Gardiner, A.F.R.Ae.S., and J. Mullin, B.Sc.(Eng.), A.F.R.Ae.S.

22nd March—Joint Meeting with the Airport Engineering Division of the Institution of Civil Engineers.

Aircraft Design with Special Reference to the Restrictions Imposed by Considerations in Airfield Design, by P. H. Watson, B.Sc., A.F.R.Ae.S.

The Problem of Airfield Design in Relation to Aircraft Design, by C. E. Foster, C.B.E., B.Sc.(Eng.), A.M.I.C.E.

31st March—Repeated Loading of Aircraft Structures, by Dr. P. B. Walker, M.A., F.R.Ae.S.

7th April—Investigation of Aircraft Accidents in Relation to Aircraft Design, by Air Commodore Vernon Brown, C.B., O.B.E., M.A., F.R.Ae.S.

21st April—AT PORTSMOUTH—High Lift Devices and Their Use, by R. R. Duddy, A.F.R.Ae.S.

(*At the Portsmouth Municipal College at* 7 *p.m.*)

28th April—The Thirty-Seventh Wilbur Wright Lecture—The Aeronautical Research Scene—Goals, Methods and Accomplishments, by Dr. Hugh Dryden, F.R.Ae.S., Director of Aeronautical Research to the National Advisory Committee of Aeronautics.

15th September—Fifth British Commonwealth and Empire Lecture—Inter-City Transport Development on the Commonwealth Routes, E. H. Atkin, B.Sc., F.R.Ae.S.

6th October—Aircraft Design Analysis Methods as Employed by the Research Division of the Bureau of Aeronautics, U.S. Navy Department, I. Driggs, F.R.Ae.S.

24th November—AT BRISTOL—A Review of Aerodynamic Cleanness, E. J. Richards, M.A., A.F.R.Ae.S.

(*At* 7.15 *p.m. at the Royal Fort Physics Laboratory, Bristol*)

1st December—The Weight Aspect in Aircraft Design, L. W. Rosenthal, A.F.R.Ae.S.

15th December—Joint Lecture with the Institute of Navigation—Navigational

Systems and Instrument Aids, Dr. D. E. Adams, B.Sc., A.Inst.P., and Dr. A. M. Uttley, B.Sc., Ph.D.

SECTION LECTURES (*Held in the Library of the Society*)

18th October—Some Considerations of the Flutter Problems of High Speed Aircraft, E. G. Broadbent, M.A., A.F.R.Ae.S.
25th October—New Methods of Aircraft Stressing, J. Hadji-Argyris, A.F.R.Ae.S.
8th November—Resonance in Aerodynamics, R. A. Shaw, M.A., A.F.R.Ae.S.
22nd November—The Design and Development of Engine Driven Gearboxes, G. W. Bubb, A.F.R.Ae.S.
6th December—The Design of Tail Pipes for Jet Engines including Re-Heat, J. L. Edwards, B.Sc., A.M.I.Mech.E.

BRANCH LECTURES AND ACTIVITIES

BELFAST BRANCH

11th January—One Thousand Miles an Hour, Professor G. T. R. Hill, M.C., M.Sc., F.R.Ae.S., M.I.Mech.E.
1st February—The Propeller-Turbine Aero-Engine, F. M. Owner, M.Sc., F.R.Ae.S., M.S.A.E.
22nd February—Lecturettes.
8th March—Helicopter Design, T. E. Goligher, B.Sc., D.I.C., A.F.R.Ae.S.
11th March—Dance.
29th March—Civil Aviation—Present and Future, P. G. Masefield, M.A., F.R.Ae.S., M.I.Ae.S., G.I.Mech.E.
5th April—Films, W. Courtenay, A.R.Ae.S.
12th April—Annual General Meeting and Films.
25th October—Air Registration Board, W. Tye, O.B.E., B.Sc., F.R.Ae.S.
22nd November—Lecturettes and Films.
13th December—Fatigue of Metallic Materials, Major P. L. Teed, A.F.R.Ae.S.

BIRMINGHAM BRANCH

8th January—Annual Dinner and Concert.
26th January—Presidential Address, Dr. S. C. Redshaw, F.R.Ae.S.
14th February—Light Aircraft, L. H. Bostock.
28th March—Stability and Flying Controls, D. J. Lyons.
29th April—Annual General Meeting and Smoking Concert.
28th October—Lecturettes.
25th November—The Investigation of Aircraft Accidents, Air Commodore Vernon S. Brown, C.B.E., O.B.E., M.A., F.R.Ae.S.

BRISTOL BRANCH

16th February—The Physics of the Nucleus, Professor C. F. Powell, M.A., Ph.D.
28th March—The Organisation of British Aeronautical Research, H. M. Garner, M.A., F.R.Ae.S.
11th April—The Aeroplane as a Commercial Product, Captain K. J. G. Bartlett.
25th April—Annual General Meeting and Film Show.
9th November—One thousand Miles an Hour? Professor G. T. R. Hill, M.C., M.Sc., F.R.Ae.S., M.I.Mech.E.
24th November—Review of Aerodynamic Cleanness, E. J. Richards, M.A., B.Sc., A.F.R.Ae.S.—MAIN SOCIETY LECTURE.
5th December—Rocket Propulsion and Interplanetory Flight, A. V. Cleaver, A.R.Ae.S.

BROUGH BRANCH

19th January—Lecturette Programme. At Brough.
16th February—Jet Engines, W. T. Winter. At Hull.
16th March—Supersonic Flight, J. R. Ewans. At Brough.

13th April—The Brabazon Aircraft, F. H. Pollicut, F.R.Ae.S. At Hull.
18th June—Second Annual Flying Display.
16th November—Stiffness and Strength, Professor A. R. Collar, M.A., D.Sc., F.R.Ae.S. At Hull.
14th December—Practical Problems in the Design and Operation of Naval Aircraft, Lt.-Cdr. E. M. Brown, A.F.C., O.B.E., D.S.C., R.N. At Hull.

COVENTRY BRANCH

20th January—Development of the Mamba Engine, W. H. Lindsey, A.F.R.Ae.S.
17th February—The Automatic Pilot, A. I. O. Davies.
17th March—Films on Radar.
27th April—Annual General Meeting and Film.
21st September—Rocket Propulsion, Air Commodore Dann.
19th October—The London-Sydney Air Route, C. H. Jackson.
16th November—Aircraft Structures, Dr. P. B. Walker, F.R.Ae.S.
14th December—Film Evening on Aircraft Materials.

DERBY BRANCH

7th February—Pictures in the Air, Charles E. Brown, F.I.B.P., A.R.P.S.
7th March—Helicopters—The Technical Point of View, Capt. R. N. Liptrot, C.B.E., B.A.
4th April—Rocket Propulsion and Inter-Planetary Flight, A. V. Cleaver, A.R.Ae.S.
2nd May—Lubrication of Aero Gas Turbines, J. G. Dawson, B.Sc., A.F.R.Ae.S.
31st October—The Cierva Air Horse, J. S. Shapiro, Dipl.Ing., A.F.R.Ae.S.
5th December—Annual General Meeting.

GLASGOW BRANCH

25th October—The Bell Helicopter, Wing Commander N. Capper.
29th November—Recent Developments in Experimental Stress Analysis, Dr. Rothman.
20th December—Annual General Meeting.

GLOUCESTER AND CHELTENHAM BRANCH

20th January—Weather Forecasting in Aviation, B. C. V. Oddie, B.Sc. At Gloucester.
16th February—The Design of an Aeroplane, Professor R. L. Lickley, B.Sc., D.I.C., F.R.Ae.S. At Cheltenham.
3rd March—Electrical Aircraft Instruments, E. B. Moss, B.Sc., F.Inst.P., M.I.Mech.E. At Gloucester.
30th March—Radar Aids in Aeronautics, S. F. Evans, M.Sc., Ph.D. At Cheltenham.
21st April—Annual General Meeting and Film on Atomic Physics. At Gloucester.
24th November—The Investigation of Air Accidents, Air Commodore Vernon S. Brown, C.B., O.B.E., M.A., F.R.Ae.S. At Cheltenham.
14th December—Problems of High Speed Flight, H. Davies, M.Sc., F.R.Ae.S. At Gloucester.

HATFIELD BRANCH

12th January—Blind Landing Technique, J. W. F. Mercer, B.Sc., A.C.G.I.
16th February—The Probable Role and Influence of Aircraft in Future Warfare, Air Marshal Sir Robert Saundby, K.B.E., C.B., M.C., D.F.C., A.F.C.
16th March—Annual General Meeting.

ISLE OF WIGHT BRANCH

20th January—Aircraft Design from the Airline Point of View, C. Dykes, M.A., A.F.R.Ae.S.
3rd February—The Probable Role and Influence of Aircraft in Future Warfare, Air Marshal Sir Robert Saundby, K.B.E., C.B., M.C., D.F.C., A.F.C.
24th February—Naval Aircraft, Lieut. Commander E. M. Brown, A.F.C., O.B.E., D.S.C., M.A., A.F.R.Ae.S.

10th March—A Lecture, N. E. Rowe, C.B.E., D.I.C., B.Sc., F.R.Ae.S.
24th March—Brains Trust.
15th October—Inaugural Dinner.
3rd November—The Development of the Brabazon I, G. P. Hebden, B.Sc., A.C.G.I., D.I.C., A.F.R.Ae.S.
17th November—Lecturettes: The American Scene, P. R. Crewe, M.A., A.F.R.Ae.S., and L. W. Rosenthal, A.F.R.Ae.S.
1st December—The Industrial Uses of the Gas Turbine, W. G. E. Lewis.
15th December—Annual General Meeting and Film Show.

LEICESTER BRANCH

12th January—Bird Flight and the Aeroplane, Captain J. L. Pritchard, Hon F.R.Ae.S.
9th February—Airscrews, E. Danvers.
9th March—Charter Flying, Squadron Leader Wright.
23rd March—Films.
13th April—Annual General Meeting and Members' Papers.

LUTON BRANCH

7th January—The Light Aeroplane and the Future of Private Flying, P. G. Masefield, M.A., F.R.Ae.S., M.I.Ae.S.
2nd February—Discussion Evening.
2nd March—Evolution of a Modern Aeroplane, Professor R. L. Lickley, B.Sc., D.I.C., F.R.Ae.S.
7th September—Air Liner Operation, a Senior Pilot and Ground Control Officer of B.O.A.C.
5th October—Film Show.
2nd November—Gas Turbine Development, by a member of the National Gas Turbine Establishment.
23rd November—Aeronautical Brains Trust.
7th December—Role of Aircraft in Future Warfare, Air Marshal Sir Robert Saundby, K.B.E., C.B., M.C., D.F.C., A.F.C.
14th December—Annual General Meeting and Presidential Address.

MANCHESTER BRANCH

27th January—Flight Testing of Civil Aircraft, P. A. Hufton, M.Sc.
24th February—The Development of the Mamba Engine, W. H. Lindsey, M.A., A.F.R.Ae.S.
17th March—Personal Experiences of Early Aerodynamic Research, Professor Sir B. Melvill Jones, C.B.E., A.F.C., F.R.S., Hon.F.I.Ae.S., F.R.Ae.S.
28th April—Rocket Propulsion and Interplanetary Flight, A. V. Cleaver, A.R.Ae.S.
21st December—Planned Servicing, Squadron Leader G. W. Kerslake.

PORTSMOUTH BRANCH

14th January—Rocket Propulsion, A. V. Cleaver, A.R.Ae.S.
11th February—Short papers by members of the Branch.
11th March—The "Debunking" of Aeronautical Sciences, C. G. Grey, F.M.R.Ae.S.
21st April—High Lift Devices and their Uses, R. R. Duddy, A.F.R.Ae.S.—MAIN SOCIETY LECTURE.
2nd December—Model Section Display.
16th December—Recent Developments in Aircraft Production Engineering, Professor J. V. Connolly, B.Eng., F.R.Ae.S.

PRESTON BRANCH

16th February—The Propeller-Turbine Aero-Engine, F. M. Owner, M.Sc., F.R.Ae.S., M.S.A.E.
9th March—Recent Developments in Aircraft Production Engineering, Professor J. V. Connolly, B.Eng., A.F.R.Ae.S.

27th April—Annual General Meeting.
7th December—Icing of Aircraft, J. K. Hardy.
15th December—Annual Dance.

READING AND DISTRICT BRANCH

20th April—Design for Production, W. Thorne.
21st September—Servicing and Maintenance of Royal Air Force Aeroplanes—Methods and Problems, Squadron Leader E. A. Harrop, O.B.E., A.F.R.Ae.S.
19th October—Atomic Energy—Its Principles and Possibilities, A. G. Salmon, B.Sc., A.Inst.P.
23rd November—History of British Airships, Lord Ventry.
7th December—Some Experiences in 40 years of Aviation, Sir Frederick Handley Page, C.B.E., Hon. F.R.Ae.S.

SOUTHAMPTON BRANCH

12th January—Gliding, A. H. Yates, B.Sc., A.F.R.Ae.S.
9th February—Radio Aids, F. R. Wills.
8th March—A Lecture, A. G. Pugsley, O.B.E., D.Sc., F.R.Ae.S.
16th November—The Role of Aircraft in War and their Probable Influence on the Future, Air Marshal Sir Robert Saundby, K.B.E., C.B., M.C., D.F.C., A.F.C.
7th December—Annual General Meeting and Discussions on Selected Topics.

WEYBRIDGE BRANCH

LECTURES

28th January—Annual Dance.
9th February—Civil Air Transport, P. G. Masefield, M.A., F.R.Ae.S., M.I.Ae.S., G.I.Mech.E.
9th March—Air Force Requirements and their Origins, Air Commodore G. W. Tuttle, C.B., C.B.E., D.F.C.
6th April—Historical Review of Aircraft Development, Sir Frederick Handley Page, C.B.E., F.R.Ae.S.
27th April—Present-Day Problems in Safety Requirements, W. Tye, O.B.E., B.Sc., F.R.Ae.S.
18th May—Junior Prize Lecture, by Branch members.
1st June—General Meeting.
19th October—The Probable Role and Influence of Aircraft in Future Warfare, Air Marshal Sir Robert Saundby, K.B.E., C.B., M.C., D.F.C., A.F.C.
9th November—The Bristol Brabazon I, F. H. Pollicut, F.R.Ae.S.
30th November—Radar and the Aircraft which use it, B. W. Hodlin, B.Sc.
21st December—Coloured Films of Aeronautical Interest, W. Courtenay, M.M., A.R.Ae.S.

VISITS

21st and 28th May—Tumblin Bay, Decompression Chamber, Wind Tunnels, Mechanical Test Department, Process Department, Erecting Shop, Drawing Office, Wisley Aerodrome.
11th June—National Physical Laboratory, Teddington.

DIVISIONS OF THE ROYAL AERONAUTICAL SOCIETY

The Council of the Society in 1948 passed a Resolution to establish Divisions of the Society in the British Commonwealth and Empire.

Under this Resolution the Divisions have power to form Branches of the Royal Aeronautical Society, similar to those formed by the Society in Great Britain.

The Council announced in March 1949 that Divisions had been formed in Australia, New Zealand and South Africa.

GRADUATE AND STUDENT SECTION

The following committee was elected at The Section's Annual General Meeting on 23rd March 1949:—

Chairman—J. W. F. Housego (Handley Page Ltd.).

Vice-Chairman—P. T. Fink (Imperial College).

Committee Members—M. K. Bowden (Northampton Engineering College), W. M. Brady (Vickers-Armstrongs Ltd), J. C. Gibbings (Queen Mary College), F. G. Irving (Imperial College), J. R. Miller (Hawker Aircraft Ltd.), J. K. Pudney (Fairey Aviation Co. Ltd.), J. G. Roxburgh (Handley Page (Reading) Ltd.), A. Stanbrook (Fairey Aviation Co. Ltd.).

Hon. Secretary: M. C. Campion (Vickers-Armstrongs Ltd.), 6a Mildenhall Road, Clapton, E.5.

Assistant Hon. Secretary: D. A. Thurgood (Vickers-Armstrongs Ltd.), Sunnyside Bungalow, Portsmouth Road, Ripley, Surrey.

Later in the year Council set up a Sub-Committee to investigate the activities of the Section and to recommend means of improving the Section. As a result of the findings the following decision was made by Council:—

> "That the Graduate and Student Committee should become a Committee of Council and should consist of nine members. Three of these should be elected by the Council of the Society. . . . Six members of the Committee should be elected by the Graduates and Students of the Society."

As a result of Council's decision the following Graduate and Student Committee of Council was appointed:—

MEMBERS OF COUNCIL: S. Scott Hall, *Fellow*, A. V. Cleaver, *Associate*, J. W. F. Housego, *Graduate*.

REPRESENTATIVES OF GRADUATE AND STUDENT SECTION: M. K. Bowden, *Student* (Northampton Engineering College), M. C. Campion, *Graduate* (Bristol Aeroplane Co. Ltd.), P. T. Fink, *Graduate* (Imperial College), J. C. Gibbings, *Graduate* (Queen Mary College), J. G. Roxburgh, *Graduate* (Handley Page (Reading) Ltd.), A. Stanbrook, *Student* (Fairey Aviation Co. Ltd.).

LECTURES

2nd March—The Development of the Brabazon I, G. P. Hebden, A.F.R.Ae.S.

23rd March—Annual General Meeting of the Section.

6th April—The Trend of Jet Engine Development, A. A. Lombard, A.F.R.Ae.S.

19th April—The Meaning and Measurement of Stability Derivatives, P. T. Fink, B.E., Grad.R.Ae.S.

3rd May—Notes on Fighter Development 1936-1948, by Jeffrey K. Quill, O.B.E., A.F.C.

12th May—Pressure Cabins, D. Cardwell, B.Sc., A.C.G.I., A.F.R.Ae.S.

13th October—Address by the President, Sir John S. Buchanan, The Time Scale in Aeronautical Engineering.

27th October—High Lift Devices, R. R. Duddy, A.F.R.Ae.S., of the Royal Aircraft Establishment.

3rd November—Hydraulic Analogy of Compressible Flow—A Substitute for the High Speed Wind Tunnel, H. Ritter, B.Sc.(Eng.), D.I.C. (Graduate), of Imperial College.

15th November—Visualisation of Air Flow at High Speeds, A. D. Young, A.F.R.Ae.S., of the College of Aeronautics.

8th December—Bonding of Aircraft Materials with Synthetic Adhesives, C. J. Moss, B.Sc., of Aero-Research Ltd.

VISITS

18th June—Croydon Airport.

10th September—London Airport.

19th November—National Physical Laboratory, Teddington.

CONVERSAZIONE

An informal Reception and Conversazione was held by the Section at 4 Hamilton Place, W.1, on 21st October.

HONORARY FELLOWSHIP

The following were awarded Honorary Fellowship of the Society in 1949:—
Lord Brabazon of Tara, M.C., Fellow of the Society, Past-President.
Sir Frederick Handley Page, C.B.E., Fellow of the Society, Past-President.
M. Louis Breguet, Breguet Aircraft Co.

MEDALS AND AWARDS

The following medals and awards were presented at the Thirty-Seventh Wilbur Wright Memorial Lecture on the 28th April 1949:—

British Gold Medal for Aeronautics

Mr. S. Camm for his outstanding work in the design and development of fighter aircraft.

British Silver Medal for Aeronautics

Lt. Commander (A) E. M. Brown, R.N., for his outstanding achievements in advancing the technique of deck landing.

Society's Bronze Medal

Captain R. N. Liptrot for his work on helicopters.

Wakefield Gold Medal

Mr. E. S. Calvert for his work on the development of airport lighting.

George Taylor (of Australia) Gold Medal

Mr. G. R. Edwards for his paper on " Problems in the Development of a New Aeroplane."

Edward Busk Memorial Prize

Mr. W. Stewart for his paper on the " Flight Testing of Helicopters."

Herbert Ackroyd Stuart Memorial Prize

Mr. W. H. Lindsey for his paper on " Development of the Armstrong Siddeley Mamba Engine."

Usborne Prize

Mr. D. R. Maguire for his paper on " Enemy Jet History."

R. P. Alston Memorial Prize

Mr. B. A. G. Mcgowan for his work in the flight testing of gliders.

BADEN-POWELL MEMORIAL PRIZE

The Baden-Powell Memorial Prize, awarded to the best candidate in the Associate Fellowship Examinations of the Society, was awarded to Mr. P. J. Wingham, Student Member, following the results of the May 1949 examinations.

THE ELLIOTT MEMORIAL PRIZE

The Elliott Memorial Prize was awarded to 582892 Cherry, R. O. G., Fitter IIE, Leading Aircraft Apprentice, the Aircraft Apprentice of the May 1946 Entry who obtained the highest marks in the General Studies Examination; to 583460 Warren, D. H., Fitter IIA, Sergeant Aircraft Apprentice, the Aircraft Apprentice of the September 1946 Entry who obtained the highest marks in the General Studies Examination; and to 583524 Robertson, A. G., F.II.A, the Aircraft Apprentice of the January 1947 Entry who obtained the highest marks in the General Studies Examination.

THE ROYAL AERONAUTICAL SOCIETY CHARTER SCHOLARSHIP

The Council decided that to mark the granting of the Charter of Incorporation to the Society a Royal Aeronautical Society Charter Scholarship should be founded. The conditions governing the award of the Scholarship are:—

1. The Scholarship shall be known as the Royal Aeronautical Society Charter Scholarship.
2. The Scholarship shall be awarded annually, or at such other times as may be decided by the Council, to assist a student wishing to undertake advanced work or study in aeronautics.
3. A Scholarship or Scholarships up to the value of £300 a year can be awarded and these Scholarships, in the first instance, will be awarded for a period of one year, although an extension of the Scholarship for a second year will be looked upon favourably by the Council if it is clear that the student and the work would benefit by such an arrangement.
4. Students wishing to apply for the Scholarship shall write to the Secretary of the Society not later than 1st June (30th June this year, 1949) stating the course they intend to follow, and giving full particulars of their age and the results of any examinations taken by them. The Scholarship will only be awarded to those who can satisfy the Council that they have the necessary qualifications to benefit, and whose proposals for work or further studies are acceptable to the Council. Normally, the work should lead to some higher degree or post-graduate diploma, although this is not essential.
5. The Council will select from the applicants those whom it considers suitable, and will call such applicants for interview in the offices of the Society before such Board as may be decided by the Society.
6. The decision of the Council on all matters concerned with the award of the Scholarship shall be final and binding.

The first award of the Charter Scholarship was made to JOHN ANTHONY DUNSBY, B.Sc., in September. Mr. Dunsby, a Student of the Society, was given a Scholarship of £300 for the year 1949-1950 and is taking a Post-Graduate Course in Aeronautics at the Imperial College of Science and Technology.

JOURNAL PREMIUM AWARDS

The following Premium Awards were made in 1949 for papers published in the Journal during 1948:—

B. Thwaites, The Production of Lift Independently of Incidence, Ten Pounds, February 1948 Journal.

H. G. Conway, M.A., F.R.Ae.S., The Kinematics of Undercarriage Retraction, Five Pounds, February 1948 Journal.

E. G. Bowen, M.Sc., Ph.D., O.B.E., Delays in the Flow of Air Traffic, Five Pounds, April 1948 Journal.

T. Pearcey, A.R.C.S., Delays in the Flow of Air Traffic and Delays in Landing of Air Traffic, Ten Pounds, April and December 1948 Journals.

Professor G. T. R. Hill, M.Sc., F.R.Ae.S., The Nature of the Distortion of Swept-Back Wings, Five Pounds, March 1948 Journal.

A. W. Morley, Ph.D., M.Sc., A.F.R.Ae.S., Equilibrium Running of the Simple Jet-Turbine Engine, Five Pounds, May 1948 Journal.

H. L. Cox, M.A., F.R.Ae.S., and E. Pribram, D.E., A.F.R.Ae.S., The Elements of the Buckling of Curved Plates, Ten Pounds each, September 1948 Journal.

D. J. Lyons, B.Sc., A.F.R.Ae.S., Some Problems of the Stability and Control of Large Aircraft, Fifteen Pounds, November 1948 Journal.

A. Robinson, M.Sc., A.F.R.Ae.S., Rotary Derivatives of a Delta Wing at Supersonic Speeds, Ten Pounds, November 1948 Journal.

J. Norman, A.F.R.Ae.S., and S. F. Wilkinson, A.R.Ae.S., Aircraft Servicing, Five Pounds each, November 1948 Journal.

THE AERONAUTICAL QUARTERLY

The Council announced in April that a new publication, *The Aeronautical Quarterly*, was to be published by the Society. Part I was published in May, Part II in August, and Part III in November.

The Aeronautical Quarterly has been founded to enable papers describing new and original work, or papers reviewing the progress in some specialised field of activity, to be published. Through the medium of its pages results of these researches are made available to all workers or design groups concerned with aviation.

To ensure that the high standard set in *The Aeronautical Quarterly* shall be maintained, the Council have been fortunate in the assistance which has been given to them by an Editorial Board and many of the leading authorities in various branches of aeronautical engineering and science who have willingly offered their co-operation to act as referees on all papers submitted for publication.

The Council of the Society was greatly encouraged to sponsor this new venture by the response it received from members of the Society to its enquiry as to the need of such a publication. The future of *The Aeronautical Quarterly* must, nevertheless, be dependent on the support it receives; it is hoped, therefore, this support will be forthcoming from all sections of the Society, so that the success of *The Aeronautical Quarterly* is assured.

The price of each issue of *The Aeronautical Quarterly* is 10/3 post paid to non-members and 7/9 to members.

The following are the contents of the first three numbers:—

PART I—MAY 1949

Flutter of Systems with Many Freedoms	W. J. Duncan
Control Reversal Effects on Swept-Back Wings	H. Templeton
Estimation of the Effects of a Parameter Change on the Roots of Stability Equations	K. Mitchell
Note on Propeller-Turbine Reduction Methods	E. C. Pike
Determination of the Drag of Jet-Propelled Aircraft in Flight	G. W. Trevelyan and D. R. Blundell
Notes on the Linear Theory of Incompressible Flow Round Symmetrical Swept-Back Wings at Zero Lift	F. Ursell
Calculation of Downwash Behind a Supersonic Wing ...	G. N. Ward

PART II—AUGUST 1949

Displacements of a Linear Elastic System under a Given Transient Load	D. Williams
Skin Friction in the Laminar Boundary Layer in Compressible Flow	A. D. Young
The Measurement of Gas Turbine Combustion Efficiency by Gas Analysis	L. J. Richards and J. C. Street
A Simplified Theory of "Simple Waves"	A. Ghaffari

PART III—NOVEMBER 1949

Surging of Axial Compressors	H. Pearson and T. Bowmer
Strain Measurement by X-Ray Diffraction Methods ...	G. B. Greenough
Buckling of a Longitudinally Stiffened Flat Panel	H. L. Cox and J. R. Riddell
Approximate Calculation of the Laminar Boundary Layer	B. Thwaites

THE CHARTER GARDEN PARTY

The Society's Annual Garden Party, the Charter Garden Party, was held on Sunday, 8th May 1949, at White Waltham Aerodrome, near Maidenhead, from 2.30 to 7 p.m. An account of the Garden Party was published in the August JOURNAL.

ACKNOWLEDGMENTS

The Council gratefully acknowledge the following gifts to the Society:—

An early Mexican book on balloon ascents, "Memorias del Fisico Aeronauta," from H. G. Conway, *Fellow*.

First Flight Air Mail Covers, from Sir Roy Fedden, *Fellow*.

An historical picture of early balloons, from the Air Registration Board.

Model of the first Canadian J.N.4 of the 1914-18 War, from Mrs. David Carnegie.

Lantern Slides, from Lord Brabazon, *Hon. Fellow*.

Books, Air Guides, Periodicals, from G. Gudmondson, *Associate*; Major B. W. Shilson, *Fellow*; Sir Oliver Simmonds, *Fellow*; Mrs. Walker Sinclair, *Companion*; and P. Steiner.

Back numbers of the JOURNAL from: A. N. Barrett, *Assoc. Fellow*; P. A. R. Bremridge, *Associate*; A. M. Desoutter, *Assoc. Fellow*; Wing Cdr. D. M. Egan, *Associate*; J. A. Finch, *Assoc. Fellow*; N. B. Garrard, *Assoc. Fellow*; P. T. Griffith; D. J. Harper, *Student*; D. F. Horne, *Assoc. Fellow*; A. Jardine, *Assoc. Fellow*; J. W. Loader, *Assoc. Fellow*; Mrs. M. B. Leak; E. S. Moult, *Fellow*; Group Capt. F. Norton, *Fellow*; S. J. Patmore, *Associate*; Mrs. Walker Sinclair, *Companion*; H. H. Smith, *Assoc. Fellow*; W. Tye, *Fellow*; Sqdn. Ldr. L. J. West, *Assoc. Fellow*; Miss M. Wilkes; and E. A. Willis, *Assoc. Fellow*.

OFFICIALS OF THE BRANCHES OF THE SOCIETY IN THE UNITED KINGDOM

BELFAST
President: Professor G. T. R. HILL, M.C., M.Sc., M.I.Mech.E., F.R.Ae.S.
Chairman: Rear Admiral M. S. SLATTERY, C.B., F.R.Ae.S., R.N. (Retd.).
Secretary: J. A. KIRK, Esq., A.F.R.Ae.S.,
Short Brothers & Harland Ltd.,
Queen's Island, Belfast, N.I.

BIRMINGHAM
President: S. C. REDSHAW, Esq., F.R.Ae.S.
Secretary: C. P. HOMES, Esq., A.R.Ae.S.,
81 Peplins Way,
Kings Norton,
Birmingham, 30.

BRISTOL
President: Air Chief Marshal Sir ARTHUR BARRATT, C.M.G., M.C.
Chairman: F. G. EVANS, Esq., B.Sc., F.R.Ae.S.
Secretary: B. P. LAIGHT, Esq., M.Sc., A.M.I.Mech.E., A.F.R.Ae.S.,
Aircraft Division,
Bristol Aeroplane Co. Ltd.,
Filton, Bristol.

BROUGH
President: R. BLACKBURN, Esq., O.B.E., A.M.I.C.E., M.I.Mech.E., F.R.Ae.S.
Chairman: G. E. PETTY, Esq., M.I.Mech.E., F.R.Ae.S.
Secretary: F. A. WILKINSON, Esq., A.F.R.Ae.S.,
Design Office,
Blackburn & General Aircraft Ltd.,
Brough, E. Yorks.

COVENTRY
President: H. M. WOODHAMS, Esq., C.B.E.,
Chairman: W. J. PETERS, Esq. [F.R.Ae.S.
Secretary: C. T. SCULTHORPE, Esq., A.F.R.Ae.S.,
Design Dept.,
Sir W. G. Armstrong Whitworth Aircraft
Baginton, Coventry. [Ltd.

DERBY
President: E. W. HIVES, Esq., C.H., M.B.E., F.R.Ae.S.
Chairman: A. G. ELLIOTT, Esq., C.B.E., F.R.Ae.S.
Secretary: J. L. BATCHELOR, Esq., A.R.Ae.S.,
154 Littleover Lane, Derby.

GLASGOW
Chairman: T. B. LYON, Esq., A.F.R.Ae.S.
Secretary: G. YOUNG, Esq., B.Sc., M.I.Ae.S.,
c/o Design Office, [A.F.R.Ae.S.,
Scottish Aviation Ltd.,
Prestwick Airport, Ayrshire.

GLOUCESTER AND CHELTENHAM
President: A. L. MILNER, Esq., Wh.Sc., A.M.I.C.E., F.R.Ae.S.
Chairman: R. W. WALKER, Esq., F.R.Ae.S.
Secretary: J. F. CUSS, Esq., A.M.I.Mech.E.,
c/o Gloster Aircraft Co. Ltd., [A.F.R.Ae.S.,
Witcombe, Gloucester.

HATFIELD
President: Sir GEOFFREY DE HAVILLAND, C.B.E., A.F.C., R.D.I., Hon.F.I.Ae.S., F.R.Ae.S.
Chairman: J. E. WALKER, Esq., A.F.R.Ae.S.
Secretary: E. J. MANN, Esq., A.M.I.Mech.E.,
de Havilland Aircraft Co. Ltd., [A.R.Ae.S.
Hatfield, Herts.

ISLE OF WIGHT
President: Sir ARTHUR GOUGE, B.Sc., M.I.Mech.E., F.R.Ae.S.
Chairman: H. KNOWLER, Esq., A.M.I.C.E., F.R.Ae.S.
Secretary: P. H. CURNOW, Esq., Grad.R.Ae.S.,
Design Office,
Saunders-Roe Ltd.,
Osborne, I.o.W.

LEICESTER
Chairman: W/Cdr. H. E. FALKNER, A.F.R.Ae.S.
Secretary: F. WATKIN, Esq., B.Sc., A.F.R.Ae.S.,
Auster Aircraft Ltd.,
Rearsby, Leicester.

LUTON
Chairman: S. A. CLARKE, Esq., A.F.R.Ae.S.
Secretary: P. A. DRILLIEN, Esq., A.R.Ae.S.,
c/o D. Napier & Son Ltd.,
Luton, Beds.

MANCHESTER
President: Sir ROY H. DOBSON, C.B.E., J.P., F.R.Ae.S.
Chairman: C. E. FIELDING, Esq., O.B.E., M.I.P.E., A.F.R.Ae.S.
Secretary: J. A. E. WATERFALL, Esq.,
56 Manor Avenue,
Ashton-on-Mersey, Cheshire.

PORTSMOUTH
President: A. TOWNSLEY, Esq.
Chairman: E. C. GREEN, Esq.
Secretary: E. M. BELLAMY, Esq.,
c/o Airspeed Ltd.,
The Airport, Portsmouth, Hants.

PRESTON
President: Sir GEORGE NELSON, M.I.Mech.E., M.I.E.E.
Chairman: W. E. W. PETTER, Esq., F.R.Ae.S.
Secretary: D. B. SMITH, Esq., O.B.E., M.A., A.M.I.Mech.E., A.F.R.Ae.S.,
English Electric Co. Ltd.,
Aircraft Division,
Warton Aerodrome, Nr. Preston, Lancs.

READING
President: Sir FREDERICK HANDLEY PAGE, C.B.E., Hon.F.R.Ae.S.
Chairman: E. W. GRAY, Esq., B.Sc., A.M.I.Mech.E., A.F.R.Ae.S.
Secretary: E. L. PEARSON, Esq., A.R.Ae.S.,
c/o Handley Page (Reading) Ltd.,
The Aerodrome, Woodley, Reading, Berks.

SOUTHAMPTON
Chairman: A. N. CLIFTON, Esq., F.R.Ae.S.
Secretary: T. TANNER, Esq., A.F.R.Ae.S.,
University College, Southampton, Hants.

WEYBRIDGE
President: G. R. EDWARDS, Esq., M.B.E., B.Sc., F.R.Ae.S.
Chairman: H. H. GARDNER, Esq., B.Sc., F.R.Ae.S.
Secretary: J. H. SINCLAIR, Esq., A.R.Ae.S.,
Vickers-Armstrongs Ltd.,
Weybridge, Surrey.

YEOVIL
Secretary: L. A. LANSDOWN, Esq., A.F.R.Ae.S.,
Westland Aircraft Ltd.,
Yeovil, Somerset.

REVIEW

MODERN METHODS FOR THE ANALYSIS OF ALUMINIUM ALLOYS. By a Committee of Chemists convened by ALAR. Chapman & Hall Ltd., London. 1949. 13s. 6d. net. 144 pp.

While books of the character of that under review have appeared before, they are rare—indeed, all too rare. This particular work owes its origin to a happy conception of the Association of Light Alloy Refiners (ALAR). This group invited a number of chemists actively engaged in controlling the production of aluminium alloys, to set out agreed methods for their analysis. This, they have done in a manner deserving of high praise in general and gentle criticism in detail.

Although metallic aluminium has been known for more than 120 years, it has only been other than a scientific curiosity for rather less than half this period, yet the number of its alloys is at once a tribute to the ingenuity of the metallurgist and to the tractability of the metal. Gruzner and Apel, in their stupendous review of aluminium alloy patents, refer to some 600 compositions. The current edition of *Metals and Alloys* indicates that something like half this number are actually manufactured. Thus it would appear that a work on the analysis of aluminium alloys would have to be of something approaching encyclopædic length, but happily this is not the case.

As is well known to those intimately associated with aluminium alloys, they fall into a number of chemical groups of which the following are the more important:—

Aluminium—Copper—Magnesium—Manganese
„ „ —Manganese—Silicon
„ „ —Nickel—Magnesium
„ „ —Lead—Bismuth
„ „ —Silicon
„ —Magnesium
„ — „ —Silicon
„ —Manganese
„ —Silicon
„ —Zinc—Copper—Magnesium—Manganese.

It is by changing the ratio of the different constituents that different alloys, often having widely different physical characteristics are evolved. Thus it comes about that the authors of the book under review have deemed it necessary to describe methods for determining the amounts of no more than 17 different elements which may be constituents of commercial aluminium alloys. To the writer this choice appears neither too narrow nor too ubiquitous.

The methods of analysis described are both chemical and physical. The former are sufficing. They cover both gravimetric and volumetric techniques, but the latter, confined as they are to electrolytic, photometric and polargraphic methods, suffer one serious omission. The invaluable services which can be rendered by the spectroscope are neglected. Admittedly the authors excuse themselves for this on the ground that the subject merits a book to itself. Here the reviewer disagrees. The present work is one of but 144 pages. Were it to be doubled in length, spectroscopic potentialities could be described and the value of the book would be increased far more than twofold.

Subject to this criticism, the book can be rightly described as, excellent in conception, good in plan, too concise in the description of the chemical principles involved in some of the analyses, but as regards the index, the less said the better. One looks forward to a further and amplified edition of what will undoubtedly already be found to be a very useful work.—P.L.T.

CORRESPONDENCE

THE AERODROME PROBLEM

While welcoming the purpose of Mr. Ayers' paper (The Aerodrome Problem Related to Aircraft Design and Operation, R. H. Ayers, September 1949 JOURNAL), to present the aerodrome as a vital factor in civil aviation, I would like to offer a few comments.

The author says that the aerodrome, to a large extent, has been taken for granted; may not this statement in itself be indicative of the detachment of the aeronautical world from its problems? A relatively small number of people have been working on these problems for the past nine or ten years, and the technique is reasonably advanced. But is the knowledge so gained sufficiently appreciated by those concerned mainly with the flying aspect? In other words, while those whose business lies with airports necessarily keep abreast of developments in aircraft design and operating technique, is this process yet sufficiently reciprocated, so that the two complementary aspects of air transport may be co-ordinated to the best advantage? Napoleon said that an army marches on its stomach: similarly, an airline marches on its ground organisation, no small part of which is provided by efficiently planned and operated aerodromes and their attendant services.

Among the factors militating in present circumstances against expanding existing aerodromes to suit operational requirements, the author omits the cost of the constructional work. More stress might have been laid throughout the paper on the enormous cost of modern aerodromes for long distance services, whether it be in the provision of a new airport or in the extension of an existing one. Air transport supplements rail and sea transport and whereas railways provide their own stations, neither ship nor airport operators do so and depend, instead, on ground traffic handling facilities provided by public bodies. Terminal facilities for both forms of transport are similar in that they are costly, the cost, however, being assessable against many miles of route. In each case, too, the return on the capital expended takes two forms. The first is to a large extent immeasurable and lies in the benefits brought to the community by improved communications: the second, or direct, return, lies in the harbour and dock dues paid by shipping and in the landing fees and hangarage charges paid by aircraft. It is a moot point, however, whether such payments are sufficient in the case of air transport, and whether the airline operator should not contribute in some way to the capital cost of the ground facilities which he seeks, instead of those falling entirely on the taxpayer. The total effect on the public should be much the same, with the advantage perhaps that the airline customer would pay more and others less, while the operators would have more say in, and should take a closer interest in, the expensive "stations" towards which they contributed. This, in turn, might react on the aircraft constructors who provide the machines, with the effect desired by Mr. Ayers.

Mr. Ayers mentions the de-centralisation of military airfields and the centralisation needed in civil airports. What is not very clearly brought out, however, is that the real focus of the airport lies in the planning and equipment of the terminal passenger and freight buildings, through which all traffic handled by the airport has ultimately to pass. The statement that the ultimate efficiency of an aerodrome must be measured in terms of the movement rate achieved should, therefore, be interpreted in terms of the quantity of passengers and freight handled in a given time, rather than in terms of the number of movements of aircraft, which are only a means to the movement of payload.

The statement that the ideal situation for a terminal apron is as near the centre of the field as can be arranged, is perhaps rather broad. When determining the

ideal location, it is usual to take into account the prevailing direction of use of the main runway, which carries the greater proportion of all traffic, and to aim at a position midway between the take-off end and the average termination of the landing run, having some regard also to similar conditions on any secondary runways. The objective is the least total taxi-ing distance, bearing in mind that usually the greater proportion of the traffic does not use the full length of a runway for landing.

An implication in the paper is that the maximum cross-wind component is the only factor which has to be considered when deciding a layout, but the topography of the site, obstructions in the approaches, and other factors may make it necessary to accept a compromise which is not ideal meteorologically. The cost of construction also enters into the picture, particularly when earthworks have to be considered. Mr. Ayers also suggests that a 20 m.p.h. cross-wind component will have to be accepted generally in the near future. While this may be so, there is a compromise which can be used in cases where the traffic using the airport is not too frequent and where the wind conditions permit. This consists, in effect, of superimposing on the top of an airport which comprises the one or two long runways required for long-distance traffic, a second layout having a greater number of runway directions to suit the smaller and lighter aircraft which will not withstand the higher cross-winds. Thus, in the ideal case, there might be, in the same layout, one long main runway which would handle all traffic on the greater percentage of occasions, plus one or more short secondary runways designed to handle lighter aircraft only. The operation of the air and ground control of the airport thereby becomes more complicated in that traffic may occasionally have to be withheld from the secondary runways in order to allow a large machine to leave or land, but the economy achieved can be great in return for a comparatively small inconvenience in operation. Extension of the shorter secondary runways can be allowed for in the master plan, and this work need only be put in hand when it is necessitated and warranted by an increasing volume of traffic. The author's advocacy of a master plan cannot be too heartily endorsed from this and other points of view.

Mr. Ayers mentions that the ideal runway length would permit re-landing the aircraft in the event of power failure occurring after take-off at a speed below safety speed, but I believe that this criterion was abandoned for general adoption, during 1944 or 1945. The cost, financial and otherwise, of the land requirements, together with the additional cost of construction, becomes so great that it exceeds the capabilities of most authorities. Nor does the idea receive much support when it is considered how small a proportion of accidents are due to this cause.

The length of secondary, or subsidiary non-instrument, runways is given as percentages only of the main, but when particular economy is desired or site conditions are difficult, the length of such runways can be calculated to a reasonable approximation to suit the wind conditions. Such a step requires a close control of aircraft movements as between the different runways, but it should be possible to achieve this with the aid of modern adaptations of meteorological instruments.

Mr. Ayers advocates a rate of descent of 800 ft. per minute, whereas 500 ft. per minute maximum is understood to be present airline practice. Considerations of the age or health of passengers enter here, and I would like to query his figure on those grounds. There are no elderly people, perhaps with sensitive hearts, included in air crews (who can also be grounded if they are suffering from a severe cold or other such affliction), but civil passengers cannot be prevented from flying except under a doctor's orders, nor can they be stopped from making their journey when they have a cold. In either case the results of too rapid ascent or descent can be painful or dangerous. Pressurisation overcomes this difficulty, but is not yet universal.

Mr. Ayers makes an excellent point about aircraft noise, a matter which has recently been the subject of correspondence in *The Times*; it is important to the community and is too readily overlooked in aerodrome planning and design. Sometimes much can be achieved by a careful choice of site and layout, and I

suggest that the reduction of ground noise over populated areas should be included in the list of important factors to which attention should be paid when considering siting and development.

In connection with that list, I do not believe that any hard and fast priority should be laid down between the different factors. The importance of each will vary with the particular airport and each should have its just measure of consideration according to the total objective desired.

Figures 2 and 3 in the paper show layouts for civil airports which appear to be extravagant in perimeter taxiways, due partly to the location of the maintenance areas and partly, perhaps, to insufficient use being made, as taxiways, of the runways not in use. Taxiways on a large airport can be surprisingly costly and must be rated approximately *pro rata* with the cost of runways, area for area. Considerable economies may be achieved by careful taxiway planning.

A. Shaw MacLaren, *Associate*, Nairobi, Kenya.
Consulting Airport Engineer.

THE AERODROME PROBLEM

I have read with considerable interest the paper by Mr. R. H. Ayers (The Aerodrome Problem), JOURNAL October 1949.

As one concerned with the whole field of air transport, I have become more and more convinced that the trend of development of the modern fixed-wing air liner is such as to rule it out of the mass markets which serve the little man.

The expense involved in furnishing the ground facilities and radio aids to navigation in the form in which they are now being developed is appalling and, consequently, the taxpayer will only be willing to bear this expense to furnish communication between large centres of population where the volume of traffic may be reckoned to justify the cost of setting up elaborate transport production machinery. This, in itself, will deprive many communities of direct air transport or, at best, will furnish them with air transport of an inconvenient and inadequate nature. Furthermore, even at the great centres of population, the present requirements are such that the airport must be removed a considerable distance away from the place where the mass of the people want to go and, consequently, the aeroplane is unable to compete with other means of transport over the shorter distances, except where there is a barrier such as the sea or a mountain range.

I have no particular quarrel with the trend of design of the long distance air liner because, as the air journey increases in length, the delays on the ground decrease in relative significance but, unfortunately, the trend apparent on the main line has unfortunate repercussions upon the secondary networks which reach to the real masses of the people. Financially, secondary networks have not been able to afford up to now the development and purchase of new aircraft especially suited to their needs and, consequently, a rise in the "standard of living" of the main line inevitably brings about an unnecessary rise in the standard of living of the branch line. When the last DC-3 (Dakota) has finally worn out and fallen to pieces, what is the secondary network industry going to do? I cannot imagine second-hand Comets landing at Yorkton, Saskatchewan, or Medicine Hat, Alberta, because an Air Transport Board could never recommend to the Government the expenditure of sufficient funds to build the airports necessary to receive and despatch such an aircraft.

I feel that the salvation of the fixed-wing aircraft in the air transport field for all but the long distance services rests upon the re-capture by the aeroplane of a large measure of its independence from elaborate ground facilities. As this affects the aeroplane designer, this means low stalling speed, small turning circle, steep angle of climb and steep rate of descent, plus independence of cross winds, all of which was mentioned by Mr. Ayers but, more important still to my mind,

is the role to be played by the expert in electronics. He has to find a simple substitute for the automatic director calculator system which man has in the form of his optical-brain system. I have personal knowledge of efforts by American Airlines which, although originally aimed at another target, have already gone a long way in the direction of solving this problem. No doubt there are corresponding developments in Great Britain. I cannot help feeling that a great deal of the aids to navigation effort that has been expended in the past has been in the nature of producing " better rubber gloves for leaky fountain pens " in the immortal words of a famous American engineer, Bill Stout by name.

Air Vice-Marshal A. Ferrier, *Fellow*, Air Transport Board, Ottawa
(now Assist. Secretary General for Air Navigation, I.C.A.O.)

MR. AYERS' REPLY

I am most grateful to Air Vice-Marshal Ferrier and Mr. Shaw MacLaren for adding so usefully to the points already made regarding the aerodrome problem. Each writer stresses the vital factor of costs as being more important than the many physical difficulties of providing landing grounds for aircraft developed and operated without adequate regard to the aerodrome problem. In Great Britain the cost factor is perhaps too well known to need stressing.

Mr. Shaw MacLaren suggests that the efficiency of the airport should be considered in terms of the movement of payload, rather than in aircraft movements. It is certainly more profitable to receive large aircraft rather than small at an aerodrome designed for large aircraft, but this opens up the wider problem of segregating classes of aircraft traffic to separate aerodromes. The traffic will only be adequate to warrant this in a few cases.

He further suggests a compromise for mixing classes of traffic and providing a system of secondary runways for smaller aircraft giving more landing directions. Of those aircraft which require a runway by virtue of their weight or undercarriage layout, it is thought that none should be incapable of accepting a 20 m.p.h. cross-wind component provided that the designers and crews work towards achieving handling characteristics and handling ability respectively to meet this demand.

I am glad that Mr. Shaw MacLaren endeavoured to side with the airline operator on the question of let-down rates as I think this argument can be, and must be, killed for all time. The let-down in question concerns only that part of the flight from 1,000 ft. to ground level which affects the safety of the flight and the level of noise to be tolerated by the community. Are the airline operators aware that lifts in New York daily ascend and descend at rates of 1,400 ft. per minute to heights of 1,000 ft.? There are no regulations that workers with colds must walk up or that those with weak hearts should do the same.

The aircraft can be operated on the approach comfortably in nil wind by normal crews at a let-down rate of 800 ft. per minute and the argument concerning passenger health is valueless in excusing long flat approaches. There can be no disagreement with the airline policy to let down from cruising altitude to circuit height at a low rate of descent, but between circuit height and ground level a higher rate of descent and ascent should be used. Mr. Shaw MacLaren stresses the importance of solving the noise problem which is becoming acute in large towns but we have one solution ready to hand by standardising glide path settings and visual descent rates at a steeper angle, which I think would soon be found acceptable to all.

R. H. Ayers.

an appreciation

THE COUNCIL OF THE ROYAL AERONAUTICAL SOCIETY WISH TO THANK THOSE COMPANIES WHO, BY THEIR GENEROUS CO-OPERATION, HAVE DONE SO MUCH TO HELP IN THE PRODUCTION OF THE JOURNAL

ACCLES & POLLOCK LIMITED

A&P
Make it with Tubes

AIRWORK LIMITED

AIRWORK
LIMITED

AEROPLANE & MOTOR ALUMINIUM CASTINGS LTD.

ALUMINIUM GRAVITY DIE CAST CYLINDER HEAD

ARMSTRONG SIDDELEY MOTORS LTD.

ARMSTRONG
SIDDELEY

AIRCRAFT MATERIALS LIMITED

AML

STRUCTURAL MATERIALS
and COMPONENTS

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD.

SIR W. G.
ARMSTRONG WHITWORTH
AIRCRAFT LIMITED

AUTOMOTIVE PRODUCTS COMPANY LTD

ALL-BRITISH Lockheed hydraulics

THE BRISTOL AEROPLANE CO. LTD

"Bristol"

AVIATION DEVELOPMENTS LTD.

AVIATION DEVELOPMENTS LTD
KINGSBOURNE HOUSE
229-231 HIGH HOLBORN, LONDON WC1
Telephone : CHAncery 8601 (8 lines)

BROOM & WADE LTD

"BROOMWADE"
AIR COMPRESSORS AND PNEUMATIC TOOLS

BIRMINGHAM ALUMINIUM CASTING (1903) CO. LTD.

BIRMAL

DOWTY EQUIPMENT LIMITED

DOWTY
UNDERCARRIAGE AND HYDRAULIC EQUIPMENT

BLACKBURN & GENERAL AIRCRAFT LTD.

BLACKBURN & GENERAL

DUNFORD & ELLIOTT (SHEFFIELD) LTD.

Dunelt
Special steels
FOR AIRCRAFT

BOULTON PAUL AIRCRAFT LTD.

BPA

DUNLOP RUBBER CO., LTD.

DUNLOP

ELECTRO-HYDRAULICS LIMITED

EH LIMITED

GLOSTER AIRCRAFT CO., LTD.

GLOSTER AIRCRAFT CO. LTD.

THE ENGLISH ELECTRIC COMPANY LTD.
LONDON

MANUFACTURERS OF AIRCRAFT, AIRCRAFT ELECTRICAL EQUIPMENT, WIND TUNNEL DRIVES, TEST PLANTS FOR RECIPROCATING AND TURBINE-TYPE ENGINES, SUPERCHARGERS, COMPRESSORS, ETC.

HANDLEY PAGE LIMITED

HP

THE FAIREY AVIATION COMPANY LTD.

ROTARY WING AIRCRAFT

FAIREY

HAWKER AIRCRAFT LIMITED

HAWKER

FIRTH-VICKERS STAINLESS STEELS LTD.

"Staynbrite Steel"

FIRTH-VICKERS STAINLESS STEELS LTD SHEFFIELD

THE HESTON AIRCRAFT CO., LTD.

HESTON AIRCRAFT

FOLLAND AIRCRAFT LIMITED

FOLLAND AIRCRAFT LTD

HAMBLE, SOUTHAMPTON

H. M. HOBSON LTD.

Hobson

F. A. HUGHES & CO., LIMITED

Distributors of

ELEKTRON

REGISTERED TRADE MARK

MAGNESIUM ALLOYS

K.L.G. SPARKING PLUGS LTD.

K·L·G

SPARKING PLUGS AND IGNITION EQUIPMENT

THE HUGHES-JOHNSON STAMPINGS LTD.

JH

KELVIN BOTTOMLEY & BAIRD LTD.

KBB

IMPERIAL CHEMICAL INDUSTRIES LTD.
(METALS DIVISION)

ICI

LIGHT-METAL FORGINGS LTD.

LMF

INTEGRAL LIMITED

INTEGRAL

HYDRAULIC PUMPS AND EQUIPMENT

LODGE PLUGS LIMITED

LODGE

PLUGS

IRVING AIR CHUTE OF GREAT BRITAIN LTD.

AIR CHUTES

IRVIN

MARTIN-BAKER AIRCRAFT CO. LTD.

M-B

MOLLART ENGINEERING CO. LTD.

ME

Members of the Gauge & Tool Makers' Association

THE PULSOMETER ENGINEERING CO. LTD.

Pulsometer

FUEL PUMPS FOR AIRCRAFT

D. NAPIER & SON LIMITED

N

A. V. ROE & COMPANY LIMITED

AVRO

THE PALMER TYRE LIMITED

'First in the Air'

Palmer

Penfold Street, Edgware Road, London, N.W.8

ROLLS-ROYCE LIMITED

ROLLS-ROYCE

AERO-ENGINES

PERCIVAL AIRCRAFT LIMITED

ROTAX LIMITED

ROTAX

AIRCRAFT ELECTRICAL ENGINEERS

PETO & RADFORD

DAGENITE

AIRCRAFT BATTERIES

SAUNDERS-ROE LIMITED

SARO

SAUNDERS-ROE LTD

OSBORNE, EAST COWES, ISLE OF WIGHT

Telephone: Cowes 445

SERCK RADIATORS LIMITED

SERCK

THE UNITED STEEL COMPANIES LIMITED

"FLYING FOX"
ELECTRIC STEELS

S. FOX & CO. LTD. SHEFFIELD

SHORT BROTHERS & HARLAND LIMITED

Shorts

Established 1908

THE FIRST MANUFACTURERS
OF AIRCRAFT IN THE WORLD

VOKES LIMITED

AMBER CROSS
TRADE MARK
Symbol of complete protection by Vokes Filters

SKYHI LIMITED

SKYHI

WESTLAND AIRCRAFT LIMITED

WESTLAND AIRCRAFT LIMITED
Yeovil, Somerset

SMITHS AIRCRAFT INSTRUMENTS LTD.

SMITHS

A. C. WICKMAN LIMITED

A.C. Wickman LIMITED
COVENTRY • ENGLAND •

SPECIALISTS IN MACHINE
TOOLS & SMALL TOOLS FOR
THE AIRCRAFT INDUSTRY

THE SPERRY GYROSCOPE COMPANY LTD.

SPERRY

YORKSHIRE ENGINEERING SUPPLIES LTD.

BRONZE FOUNDRIES

YESEATONIA

BEARINGS AND BUSHES

DIRECTORY OF ADVERTISERS

ACCLES & POLLOCK LTD.	Paddock Works, Oldbury, Birmingham	Broadwell 1500
AEROPLANE & MOTOR ALUMINIUM CASTINGS LTD.	Wood Lane, Erdington, Birmingham	Erdington 2207-9
AIRCRAFT MATERIALS LTD.	Midland Road, London, N.W.1	Euston 6151
AIRSPEED LTD.	The Airport, Portsmouth	Portsmouth 74631
AIRWORK LTD.	15 Chesterfield Street, London, W.1	Grosvenor 4841
ALBRIGHT & WILSON LTD.	49 Park Lane, London, W.1	Grosvenor 1311
ALVIS LTD.	Holyhead Road, Coventry	Coventry 5501
ARMSTRONG SIDDELEY MOTORS LTD.	Parkside, Coventry	Coventry 4061
ARMSTRONG WHITWORTH AIRCRAFT, SIR W. G., LTD.	Whitley, Coventry	Coventry 61061-4
AUTOMOTIVE PRODUCTS CO. LTD.	Tachbrook Road, Leamington Spa	Leamington Spa 1700
AVIATION DEVELOPMENTS LTD.	229 High Holborn, London, W.C.1	Chancery 8601
BIRMINGHAM ALUMINIUM CASTING (1903) CO. LTD.	Birmid Works, Smethwick, Birmingham, 40	Smethwick 1431
BLACKBURN AND GENERAL AIRCRAFT LTD.	Head Office: Brough, E. Yorks.	Brough 121
	Feltham Factory: Feltham, Middlesex	Feltham 3636
	London Office: 11 Upper Grosvenor Street, W.1	Grosvenor 3813
BOOTH, JAMES & CO. LTD.	Argyle Street Works, Nechells, Birmingham, 7	Birmingham E. 1221
BOULTON PAUL AIRCRAFT LTD.	Wolverhampton, Staffs.	Fordhouses 3191
BRISTOL AEROPLANE CO. LTD., THE	Filton House, Bristol	Bristol 48051
BRITISH BELTING AND ASBESTOS LTD.	Cleckheaton, Yorks.	Cleckheaton 800
	59 Southwark Street, London, S.E.1	Hop. 0192
BRITISH MESSIER LTD.	Cheltenham Road East, Gloucester	Churchdown 3281
BRITISH OVERSEAS AIRWAYS CORPORATION	Headquarters: Stratton House, Stratton Street, W.1	Mayfair 6611
	Traffic Enquiries: Airways Terminal, Buckingham Palace Road, S.W.1	Victoria 2323
BRITISH THOMSON-HOUSTON CO. LTD.	Lower Ford Street, Coventry	Coventry 4104
BROOM & WADE LTD.	High Wycombe, Bucks.	High Wycombe 1630
DAVID BROWN & SONS (HUDDERSFIELD) LTD.	Park Gear Works, Huddersfield	Huddersfield 3500
DAVID BROWN FOUNDRIES COMPANY	Penistone, near Sheffield	Penistone 135
DE HAVILLAND AIRCRAFT CO. LTD., THE	Hatfield Aerodrome, Herts.	Hatfield 2345
DOWTY EQUIPMENT LTD.	Cheltenham, Gloucester	Cheltenham 53471
DUNFORD & ELLIOTT (SHEFFIELD) LTD.	Attercliffe Wharf Works, Sheffield, 9	Sheffield 41121-4
DUNLOP RUBBER CO. LTD.	Fort Dunlop, Erdington, Birmingham, 24	Erdington 2121
ELECTRO-HYDRAULICS LTD.	Liverpool Road, Warrington	Warrington 2244
ENGLISH ELECTRIC CO. LTD.	Stafford	Stafford 700
FAIREY AVIATION CO. LTD.	Hayes, Middlesex	Hayes 3800
FIRTH, THOS. AND JOHN BROWN LTD.	Atlas and Norfolk Works, Sheffield, 1	Sheffield 20081, 26491
FIRTH-VICKERS STAINLESS STEELS LTD.	Staybrite Works, Sheffield	Sheffield 42051
FOLLAND AIRCRAFT LTD.	Hamble, Southampton, Hants.	Hamble 3191
GLOSTER AIRCRAFT CO. LTD.	Gloster Works and Aerodrome, Hucclecote, Glos.	Gloucester 66294
GRAVINER MANUFACTURING CO. LTD.	(Aircraft Division Sales Dept.), Poyle Mill Works, Colnbrook, Bucks.	Colnbrook 48-49
HANDLEY PAGE LTD.	Cricklewood, London, N.W.2	Gladstone 8000
HAWKER AIRCRAFT LTD.	Canbury Park Road, Kingston-on-Thames	Kingston 1044
HESTON AIRCRAFT CO. LTD., THE	Heston Airport, Middlesex	Southall 2321
HIGH DUTY ALLOYS LTD.	Slough, Bucks.	Slough 21201
HOBSON, H. M., LTD.	Hobson Works, Fordhouses, Wolverhampton	Fordhouses 2266
HUGHES, F. A., & CO. LTD.	Bath House, 82 Piccadilly, London, W.1	Grosvenor 6300
HUGHES-JOHNSON STAMPINGS LTD., THE	Langley Green, Birmingham	Broadwell 1361
ILIFFE AND SONS LTD.	Dorset House, Stamford Street, London, S.E.1	Waterloo 3333
IMPERIAL CHEMICAL INDUSTRIES LTD.	Nobel House, 2 Buckingham Gate, London, S.W.1.	Victoria 4444
IMPERIAL CHEMICAL INDUSTRIES LTD. (METALS DIVISION)	Kynoch Works, Witton, Birmingham, 6	Birchfield 4848
INTEGRAL LTD.	Cousins Street, Dudley Road, Wolverhampton	Wolverhampton 24984
IRVING AIR CHUTE OF GREAT BRITAIN LTD.	Ickneild Way, Letchworth, Herts.	Letchworth 888
K.L.G. SPARKING PLUGS LTD.	Putney Vale, London, S.W.15	Putney 2671
KELVIN, BOTTOMLEY & BAIRD LTD.	Kelvin Avenue, Hillingdon, Glasgow, S.W.2	Halfway 3331
	Kelvin Works, Basingstoke	Basingstoke 690
LIGHT-METAL FORGINGS LTD.	Oldbury, Birmingham	Broadwell 1152
LODGE PLUGS LTD.	Rugby	Rugby 2076
MARSTON EXCELSIOR LTD.	Wolverhampton	Fordhouses (W'ton) 2181
	49/59 Armley Road, Leeds, 12	Leeds 37351 Armley 38081-5
MARTIN-BAKER AIRCRAFT CO. LTD.	Higher Denham, Bucks.	Denham 2214
MOLLART ENGINEERING CO. LTD.	Kingston By-Pass, Surbiton, Surrey	Elmbridge 3352-4
MOND NICKEL CO. LTD., THE	Grosvenor House, Park Lane, London, W.1	Grosvenor 4131
MUREX WELDING PROCESSES LTD.	Waltham Cross, Herts.	Waltham Cross 3636

DIRECTORY OF ADVERTISERS

NAPIER D., & SON LTD.	Acton, London, W.3	Shepherds Bush 122
PALMER TYRE LTD., THE	Herga House, Vincent Square, London, S.W.1	Victoria 8323
PERCIVAL AIRCRAFT LTD.	Luton Airport, Luton, Beds.	Luton 2960
PETO & RADFORD	Chequers Lane, Dagenham, Essex	Rainham 34
PITMAN, SIR ISAAC & SONS LTD.	Parker Street, Kingsway, London, W.C.2	Holborn 9791
PULLIN, R. B., & CO. LTD.	Phoenix Works, Great West Road, Brentford, Middx.	Ealing 0011-3, 3661-3
PULSOMETER ENGINEERING CO. LTD., THE	Nine Elms Iron Works, Reading.	Tilehurst 67182-4
	39 Victoria Street, London, S.W.1	Abbey 4565
QANTAS EMPIRE AIRWAYS	c/o British Overseas Airways Corporation, Airways Terminus, Buckingham Palace Road, S.W.1	Victoria 3126
The R.A.F. Quarterly	Gale & Polden Ltd., Ideal House, Argyll Street, W.1	Gerrard 4171
ROE, A. V., & CO. LTD.	Greengate, Middleton, Manchester	Failsworth 2020-2039
ROLLS-ROYCE LTD.	Derby	Derby 2424
ROTAX LTD.	Willesden Junction, London, N.W.10	Elgar 7777
ROTOL LTD.	Cheltenham Road, Gloucester	Gloucester 24431
SANGAMO WESTON LTD.	Great Cambridge Road, Enfield, Middlesex	Enfield 3434 & 1242
SAUNDERS-ROE LTD.	Head Office: Osborne, E. Cowes, Isle of Wight	Cowes 445
	London Office: 45 Parliament St., Westminster, S.W.1	Whitehall 7271
SERCK RADIATORS LTD.	Warwick Road, Birmingham, 11	Victoria 0531
SHELL-MEX AND B.P. LTD.	Shell-Mex House, Strand, London, W.C.2	Temple Bar 1234
SHORT BROTHERS AND HARLAND LTD.	Seaplane Works, Queen's Island, Belfast	Belfast 58444
SKYHI LTD.	"Skyhi" Works, Worton Road, Isleworth, Middlesex	Hounslow 2211
SMITHS AIRCRAFT INSTRUMENTS LTD.	Cricklewood Works, London, N.W.3	Gladstone 3333
SOZOL (1924) LTD.	2 Copthall Buildings, London, E.C.2	Monarch 6830
SPERRY GYROSCOPE CO. LTD., THE	Great West Road, Brentford, Middlesex	Ealing 6771
TEMPLE PRESS LTD.	Bowling Green Lane, London, E.C.1	Terminus 3636
UNITED STEEL COMPANIES LTD., THE	17 Westbourne Road, Sheffield, 10	Sheffield 60081
VICKERS-ARMSTRONGS LTD.	Vickers House, Broadway, Westminster, S.W.1	Abbey 7777
	Weybridge Works, Weybridge, Surrey	Byfleet 240-243
	Supermarine Works, Hursley Park, Winchester, Hants.	Chandlersford 2251
VOKES LTD.	Henley Park, near Guildford, Surrey	Guildford 62861
WAKEFIELD, C. C., & CO. LTD.	46 Grosvenor Street, London, W.1	Mayfair 9232
WESTLAND AIRCRAFT LTD.	Yeovil, Somerset	Yeovil 1100
WICKMAN, A. C., LTD.	Tile Hill, Coventry	Tile Hill 66271
WIGGIN, HENRY, & CO. LTD.	Wiggin Street, Birmingham	Edgbaston 2245
YORKSHIRE ENGINEERING SUPPLIES LTD.	Bronze Foundries, Upper Wortley Road, Leeds, 12	Leeds 38234 & 38291

The Journal is published monthly at the Offices of the Society, 4 Hamilton Place, Piccadilly, London, W1. None of the papers or paragraphs must be taken as expressing the opinion of the Council of The Royal Aeronautical Society unless such is definitely stated to be the case. Subscriptions per annum, £4 13 0 including postage: Single Numbers 7/6 or 7/9 post free. All communications for publication or Advertisements in the Journal, or on general matters affecting the Society should be addressed to—The Secretary, J. Laurence Pritchard, 4 Hamilton Place, W1. The Society's Bankers are Messrs. Coutts & Co.

Telephone: Grosvenor 3515 (5 lines). Telegraphic Address: Didaskalos, Audley, London.

THE AERONAUTICAL QUARTERLY

Volume I MAY 1949 Part I

CONTENTS

Foreword

Control Reversal Effects on Swept-Back Wings — *H. Templeton*

Calculation of Downwash behind a Supersonic wing — *G. N. Ward*

Estimation of the Effect of a Parameter Change on the Roots of Stability Equations — *K. Mitchell*

Flutter of Systems with Many Freedoms — *W. J. Duncan*

Note on Propeller-Turbine Reduction Methods — *E. C. Pike*

Determination of the Drag of Jet-Propelled Aircraft in Flight — *G. W. Trevelyan* and *D. R. Blundell*

Notes on the Linear Theory of Incompressible Flow round Symmetrical Swept-Back Wings at Zero Lift — *F. Ursell*

LONDON
ROYAL AERONAUTICAL SOCIETY
4 HAMILTON PLACE, W1

10/-

THE AERONAUTICAL QUARTERLY

Volume I AUGUST 1949 Part II

CONTENTS

Displacements of a Linear Elastic System Under a Given Transient Load — *D. Williams*

Skin Friction in the Laminar Boundary Layer in Compressible Flow — *A. D. Young*

The Measurement of Gas Turbine Combustion Efficiency by Gas Analysis — *L. J. Richards* and *J. C. Street*

A Simplified Theory of "Simple Waves" — *A. Ghaffari*

LONDON
ROYAL AERONAUTICAL SOCIETY
4 HAMILTON PLACE, W1

10/-

THE AERONAUTICAL QUARTERLY

Volume I NOVEMBER 1949 Part III

CONTENTS

Surging of Axial Compressors — *H. Pearson* and *T. Bowmer*

Strain Measurement by X-Ray Diffraction Methods — *G. B. Greenough*

Buckling of a Longitudinally Stiffened Flat Panel — *H. L. Cox* and *J. R. Riddell*

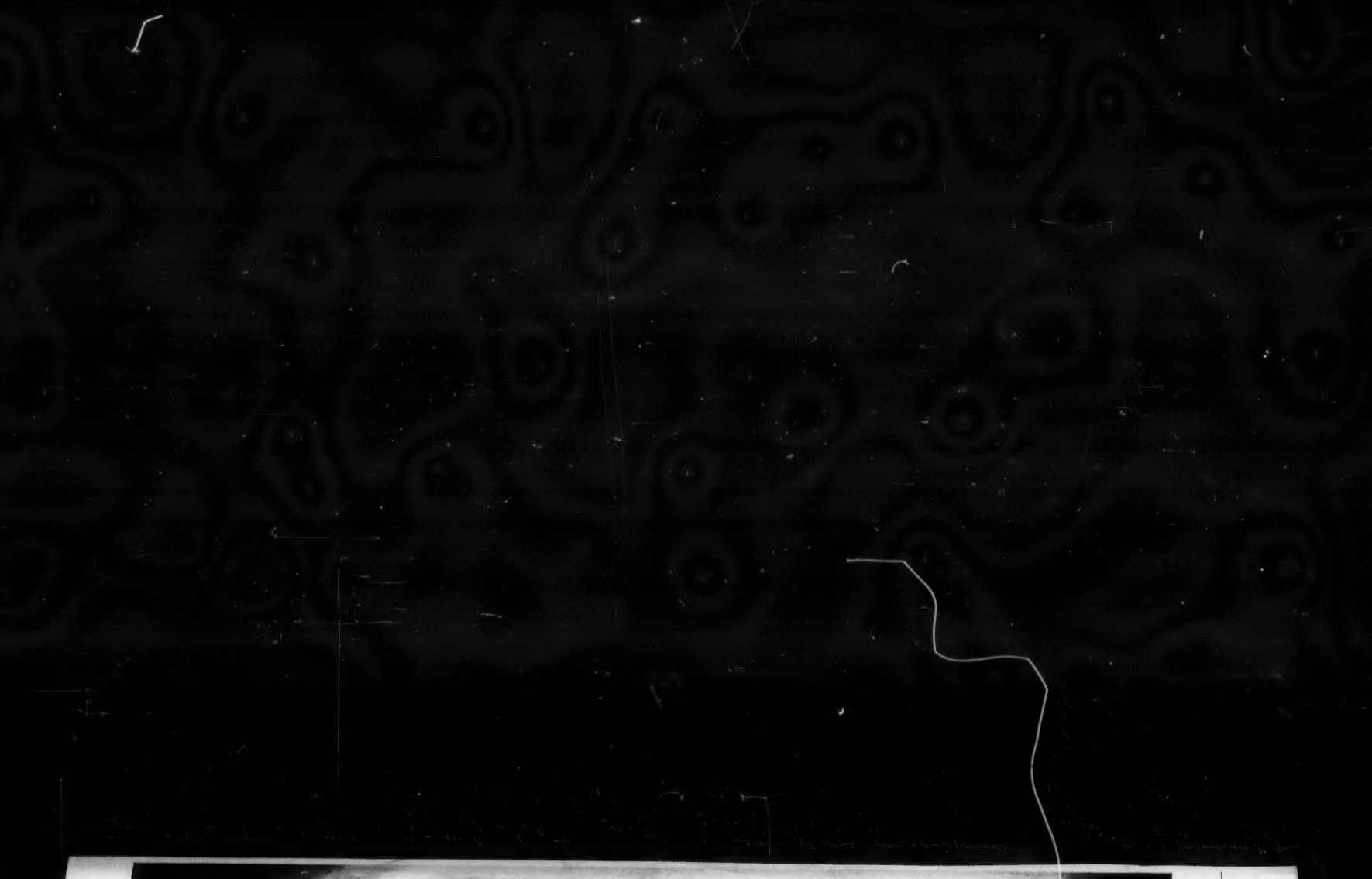
Approximate Calculation of the Laminar Boundary Layer — *B. Thwaites*

LONDON
ROYAL AERONAUTICAL SOCIETY
4 HAMILTON PLACE, W1

10/-

RESERVED FOR PART IV FEBRUARY 1950

Reduced price to members 7/6

Subscriptions for Volume I are still available

Printed by the LEWES PRESS (Wightman & Co. Ltd.), Friars Walk, Lewes, England, and Published by
THE ROYAL AERONAUTICAL SOCIETY, 4 Hamilton Place, London, W.1, England.